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// MONTHLY WEATHER REVIEW

CLEVELAND ABBE, Editor.

VOL. 43, No. 3. W. B. No. 550. MARCH, 1915 CLOSED MAY 3, 1915 ISSUED JUNE 2, 1915

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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports of climatological data for the respective States, Territories, and colonies.

Since December, 1914, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.*—Results of observations by Weather Bureau observers and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions that during recent years were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW, but collected and published by States at selected sections centers.

The data needed in section 7 can only be collected and prepared several weeks after the close of the month whose name appears on the title page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are specially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Central Meteorological and Magnetic Observatory of Mexico.
The Director General of Mexican Telegraphs.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.
The General Superintendent United States Life-Saving Service.

SECTION I.—AEROLOGY.

THE TOTAL RADIATION RECEIVED ON A HORIZONTAL SURFACE FROM THE SUN AND SKY AT WASHINGTON, D. C.

HERBERT H. KIMBALL, Professor in Charge of Solar Radiation Investigations.

[Dated: Washington, D. C., March 23, 1915.]

Apparatus.—The reader is referred to this REVIEW for August, 1914, 42:474–487, for a description of the Callendar pyrheliometer, the method by which it has been standardized, and a summary of the radiation measurements obtained by means of it at Mount Weather, Va., between May, 1912, and September, 1914.

Exposure.—In Table 1 of this paper are summarized in a similar manner measurements obtained at the Central Office of the Weather Bureau, Washington, D. C., between July, 1909, and April, 1912. Callendar pyrheliometer No. 7016 was employed in making the measurements. It was exposed on the top of a 50-foot tower erected on the roof of one of the Weather Bureau buildings, and recorded by a Callendar self-adjusting Wheatstone bridge. The pyrheliometer was about 150 feet (46 meters) above sea level. It had practically unobstructed exposure to the sky in all directions down to the true horizon. This pyrheliometer is similar to those described and illustrated in the REVIEW for August, 1914, above referred to, except that it consists of two platinum grids instead of four, and in consequence the blackened and the bright grids each occupy one side of a square instead of diagonally opposite corners of it.

The records were made on 75th meridian time, and the third column of Table 1 shows how many minutes the register clock was faster than the sun.

Reduction of records.—Pyrheliometer No. 7016 has not been subjected to the rigorous tests applied to No. 13129, with which the Mount Weather records were obtained. The radiation equivalent of tenth of an inch spaces on the record sheets,[1] as derived from the Callendar certificates for these two instruments, with No. 13129 recording on a Leeds & Northrup register, is in each case 0.0247. The reduction factors given in Table 8 of the REVIEW for August, 1914,[2] have therefore been employed in reducing to heat units the records from Callendar pyrheliometer No. 7016, summarized below in Table 1.

At the end of September, 1914, Callendar pyrheliometer No. 13129 was removed from Mount Weather, and installed on the top of a ventilating flue of the College of History Building, American University, Washington, D. C.[3] It is about 451 feet (137 meters) above sea level, and there is practically no obstruction between it and the sky in any direction down to the true horizon. It records on the same Leeds & Northrup register that was employed at Mount Weather; and its records have been reduced to heat units by the use of the factors there determined. The records are summarized in Table 2. The register clock is set to keep apparent or true solar time.

There is some evidence that with the present installation of pyrheliometer No. 13129 internal reflection from the glass cover causes it to record relatively too little radiation when the sun is near the horizon.[4] The data of Table 2 may, therefore, require a slight correction, the amount of which will be determined after a longer series of observations has been obtained.

Daily extremes.—In Table 3, columns 5 and 6, are given the maximum and the minimum daily amounts of solar and sky radiation that have been recorded at Washington in the consecutive decades covered by the records. In figure 1, trace I (○), are plotted the absolute daily maxima for each decade throughout the year, as derived from Table 3, column 5. These maxima represent the daily amounts of radiation received in each decade when the sky is clearest. Figure 1, trace I, is therefore the curve of annual variation in the possible daily radiation for Washington, and the "Percentage of possible radiation" given in Tables 1 and 2 has been obtained by dividing the "Daily average" for each decade by the possible daily radiation for the corresponding decade, as derived from this trace.

The percentage of possible sunshine has been obtained from the record of sunshine by the Marvin sunshine recorder installed at the central office of the Weather Bureau, and the mean daily cloudiness from the eye estimates of cloudiness entered in the Daily Meteorological Record for the Washington station.

Maximum solar radiation at normal incidence.—In figure 2, trace I (+) represents the monthly maxima of solar radiation intensities at normal incidence at Washington. It is based on measurements made at the central office of the Weather Bureau between December, 1905, and February, 1912, and at the American University from October, 1914, to date. These maxima have usually occurred shortly before noon.

It is to be noted that while a maximum of 1.50 calories per minute per square centimeter of area has been recorded in February there is but little variation in the monthly maxima from November to April, inclusive. The lowest monthly maximum, 1.40 calories, has been recorded in June and August. These maxima exceed those for Mount Weather for the cold months November to February, inclusive, and are below those for Mount Weather from May to October, inclusive.[5] The lower maxima at Washington during the summer months are to be attributed to the accumulation of dust and moisture in the lower layers of the atmosphere at this season of the year. As already explained in connection with the Mount Weather data, the high solar radiation intensities of winter, with the sun more than 60° from the zenith, as compared with the intensities in summer with the sun less than 20° from the zenith, are to be attributed to the small amount of dust and moisture in the atmosphere in winter, and the relative nearness of the earth to the sun at that season.

[1] MONTHLY WEATHER REVIEW, August, 1914, 42:477, fig. 5.
[2] MONTHLY WEATHER REVIEW, August, 1914, 42:480.
[3] MONTHLY WEATHER REVIEW, December, 1914, 42:648.

[4] Mr. Eric R. Miller has called my attention to the fact that in this REVIEW, August, 1914, 42:478-9, the effect of internal reflection from a hemispherical glass envelope is not given proper consideration.
[5] MONTHLY WEATHER REVIEW, August, 1914, 42:484-5.

The reason for the relatively low monthly maxima at Mount Weather during the winter is not apparent.

Maximum solar and sky radiation on a horizontal surface.—In Table 3, columns 3 and 4, are given the maximum radiation per minute, and the maximum recorded in any one hour by the Callendar recorder, in the successive decades. The hourly maximum is recorded in the hour just preceding or following noon on a clear day. The maximum rate per minute usually occurs when clouds surround the sun, but do not obscure it.

The absolute decade maxima of columns 3 and 4, respectively, have been plotted in figure 2 as traces II (○) and III (●), the hourly rates of column 4 having first been reduced to minute rates. As was explained in connection with similar curves for Mount Weather,[6] trace II exceeds trace III principally because of heat reflection from cloud surfaces. The increase from this source in the maximum rates of radiation received on a horizontal surface averages about 0.15 calorie per minute.

Decade means.—The decade averages of solar and sky radiation for each hour of the day as given in Table 1 have been plotted with 75th meridian time as abscissæ and the hourly amounts of radiation as ordinates. The hour lines for each decade were then shifted by the number of minutes that Table 1, column 3, shows are necessary to obtain apparent time, and the amounts of radiation corresponding to these new hour lines were read off.

From the decade averages thus determined, together with those of Table 2, mean values of the hourly and daily solar and sky radiation for Washington for each decade throughout the year have been computed. Similar means have also been computed for Mount Weather from the decade averages given in the REVIEW for August, 1914, **42**:482, Table 9.

[6] MONTHLY WEATHER REVIEW, August, 1914, 42:484.

On account of the short period during which records were obtained at each of these stations, the means as computed above have been smoothed by the equation $m=\frac{1}{3}(a+b+c)$, where b is the mean for the decade for which the smoothed mean, m, is to be computed, and a and c are the means for the preceding and following decades, respectively. In this way means have been computed for 36 overlapping monthly periods throughout the year, commencing with the 1st, 11th, and 21st of the consecutive months. The smoothed means thus determined for the daily amounts of radiation have been plotted in figure 1, trace II, the crosses (+) representing the data for Washington, and the filled circles (●) the corresponding data for Mount Weather. It will be noted that there is close agreement between these data during the first half of the year, but that the Washington data is generally the higher by a few per cent during the last half of the year.

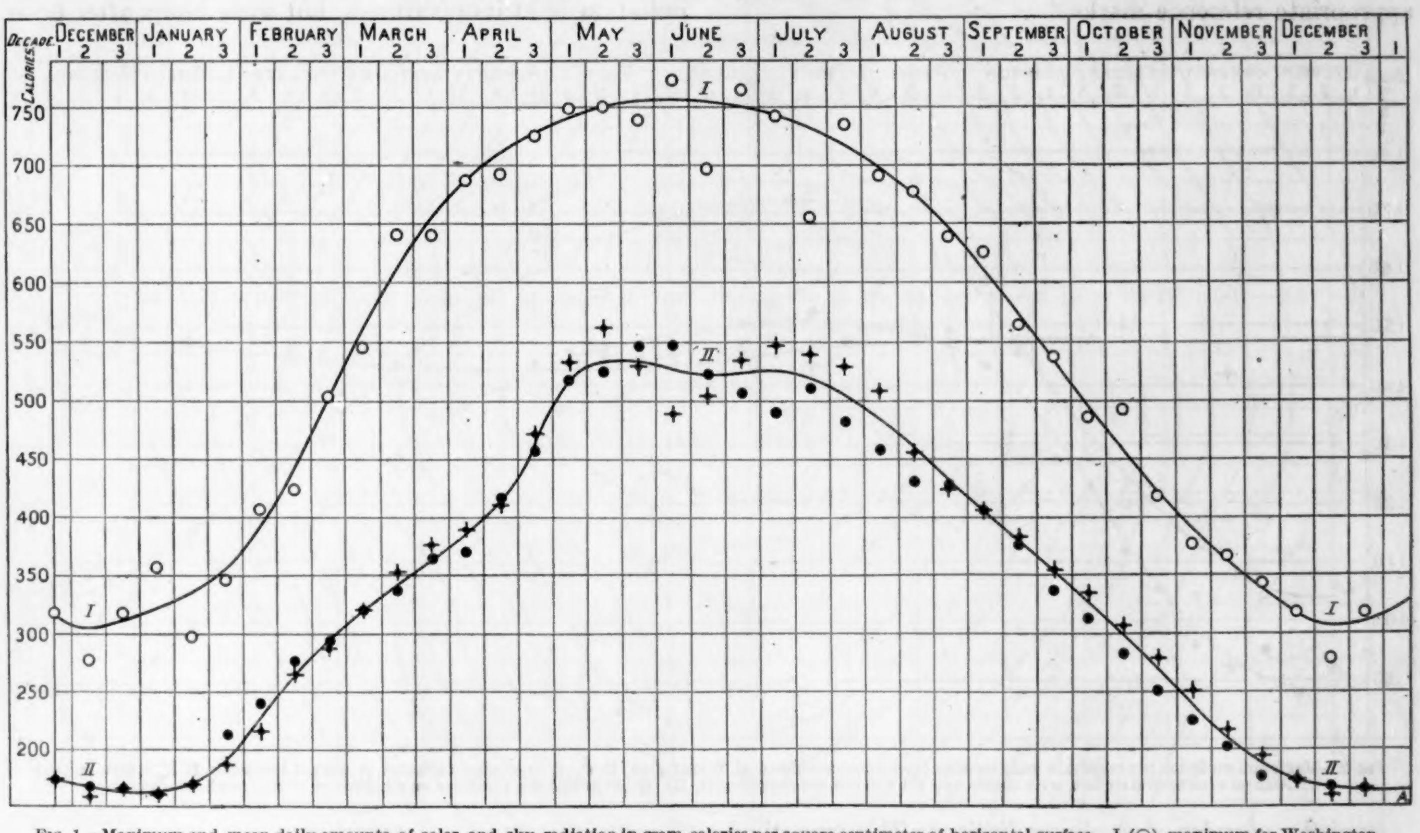

FIG. 1.—Maximum and mean daily amounts of solar and sky radiation in gram-calories per square centimeter of horizontal surface. I (○), maximum for Washington, D. C.; II (+), mean for Washington, D. C.; III (●), mean for Mount Weather, Va.

In the data for both stations there is evidence of a maximum of radiation in May, and of a secondary minimum in June or July, followed by a secondary maximum.

Daily normals and departures of solar and sky radiation.—In drawing figure 1, trace II, consideration was given to the data for both Washington and Mount Weather, and it is probable that this trace represents the annual variation in the daily amounts of radiation received at each station better than would separate curves based on the data for the respective stations.

In Table 4, column 2, are given the daily normals of radiation for Washington and Mount Weather as read off from figure 1, trace II. In the following columns are given the daily departures from these normals, and the "Total excess or deficiency since the first of the month." In the footings are also given these totals from the first of the year.

Daily totals of radiation.—The algebraic sum of the daily normal and daily departure will give the daily amount of radiation as measured. The daily departures, and the total excess or deficiency of radiation since the first of the month or since the first of the year, respectively, contain whatever errors there may be in the normals. They should be used with caution, therefore, especially when comparing data obtained at the two stations. They probably show the time of occurrence of periods of excess or deficiency of radiation, without accurately measuring the amount of this excess or deficiency.

When the record for a part or the whole of a day is missing, it has seemed better to supply it from records for other days having the same amount of sunshine, rather than to leave it blank. The days on which data have been supplied in this way are indicated in Table 4 by appropriate reference marks.

The lines of zero radiation have been determined from the average time of sunrise and sunset given in Table 1, column 2, for each decade.

These isopleths of radiation may be compared with the thermo-isopleths for Washington prepared by Cleveland Abbe, jr., and reproduced in figure 1, page 113, of this REVIEW. It is significant that the monthly mean diurnal range of temperature for Washington reaches a maximum of 20.2°F. in May, at the time the diurnal solar and sky radiation reaches its maximum, and a minimum of 15.4°F. in December, at the time the diurnal radiation reaches its minimum. The times of occurrence of the seasonal maximum and minimum temperatures are, of course, retarded as compared with the times of occurrence of the maximum and the minimum daily amounts of radiation, just as the maximum temperature for the day occurs not at noon, the time when the radiation is at its maximum, but some hours after noon.

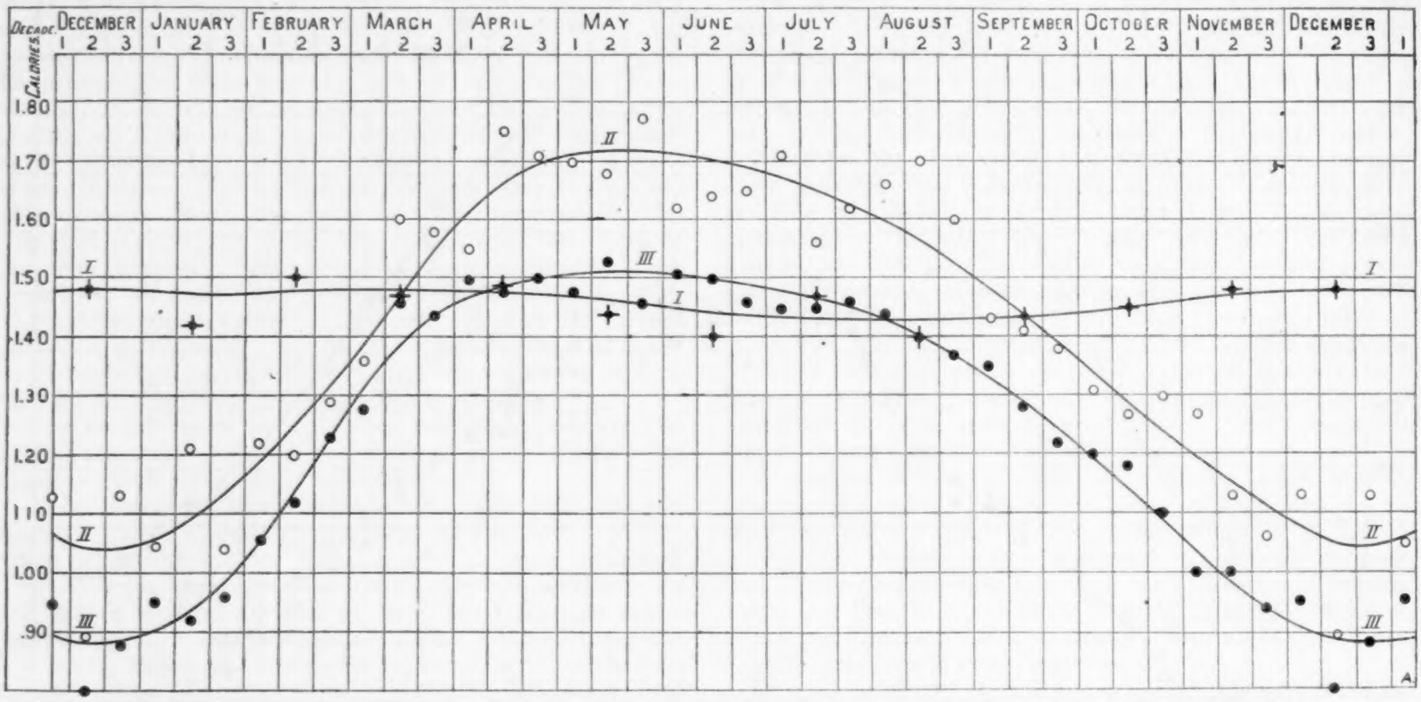

FIG. 2.—Maximum radiation per minute in gram-calories per square centimeter at Washington, D. C. I (+), solar radiation at normal incidence; II (○), solar and sky radiation on a horizontal surface, with clouds near the sun but not obscuring it; III (●), solar and sky radiation on a horizontal surface, with cloudless sky.

Isopleths of solar and sky radiation.—The smoothed decade means of solar and sky radiation for Washington for different hours of the day were plotted with apparent time as abscissas and the decades as ordinates. For the months of May and June, with data for only two years available, the decade means were so irregular that they were still further smoothed by combining them with the decade means for Mount Weather, giving each equal weight. It will be noted from figure 1, trace II, that during the six decades of these two months the decade means of daily radiation for Washington were higher than those for Mount Weather on three decades and lower on three decades. Isopleths of solar and sky radiation thus determined are reproduced in figure 3, the lines for the months of May and June being broken to indicate that they are not so well determined as those for other months. The isopleths show a maximum of radiation in May, a secondary maximum in July, and a secondary minimum between them, all of which persist practically from sunrise to sunset.

SUMMARY.

The Callendar records of solar and sky radiation obtained at Washington show slightly higher daily totals on clear days than do the corresponding records for Mount Weather. Trace II, figure 1, shows that the mean daily amounts are nearly the same at the two stations during the first half of the year, but that the Washington means are slightly higher during the second half of the year.

Trace I, figure 1, shows that the daily totals for Washington on clear days are higher during the first half of the year than during the second half, as was the case at Mount Weather, and that the maximum occurs early in June.

Although the mean daily radiation for Washington reaches a maximum in May, as shown by Trace II, figure 1, it averages higher during the second half of the year than during the first half, on account of the greater average cloudiness during the spring months than during the fall months.

The isopleths of solar and sky radiation, figure 3, give a graphic picture of the rates at which heat energy is received from the sun and sky throughout the year. Since the heat energy thus received is not only the cause of both the seasonal and the diurnal temperature variations, but also of all atmospheric movements, and consequently of all weather changes, the data here presented should be of special value to meteorologists and biologists.

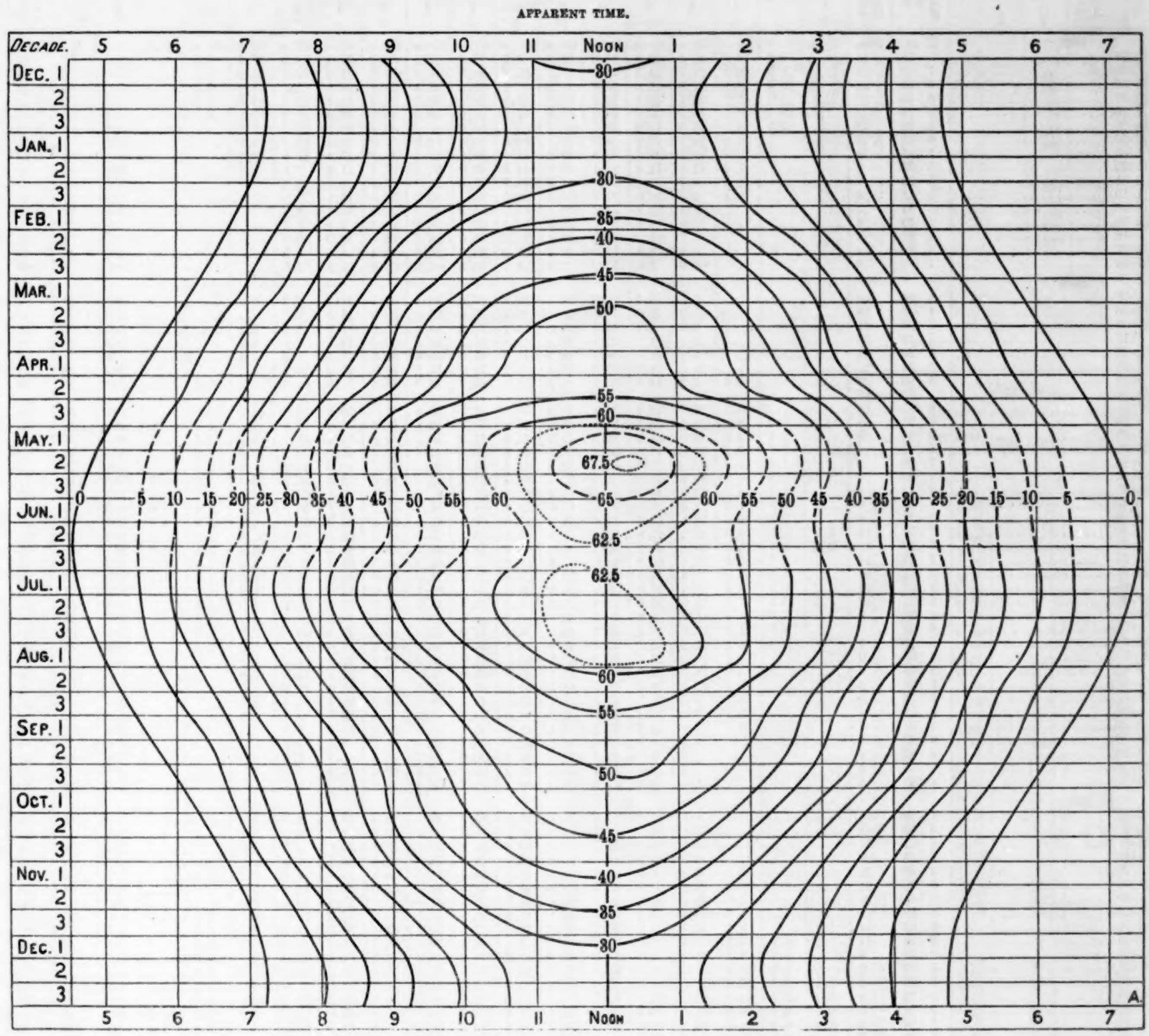

FIG. 3.—Isopleths of solar and sky radiation for Washington, D. C. (Gram-calories per hour per square centimeter of horizontal surface.)

TABLE 1.—*Solar and sky radiation, expressed in gram-calories per square centimeter of horizontal surface, at Washington, D. C.*

[Central Office of the Weather Bureau, Lat. 38° 54′ N.; long. 77° 03′ W. Altitude, 46 meters.]

Decade.	Mean solar h. a. at sunrise and sunset.	Register clock faster than sun.	Decade average during hours ending (seventy-fifth meridian time)—																Daily average.	Per cent of possible radiation.	Per cent of possible sunshine.	Mean daily cloudiness.
			A. M.								P. M.											
			5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8				
	H. m.	Min.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	Gr.-c.	%	%	0-10
1909.																						
July 24-31	7 11	+14	......	2.9	14.0	26.4	40.9	56.8	66.8	70.1	71.4	57.6	50.9	38.3	33.8	17.7	5.6	0.4	554	77	74	4
Aug. 1-10	7 01	14	......	1.9	9.4	20.7	34.0	47.6	57.3	65.8	69.0	64.8	54.0	44.6	28.2	15.8	4.5	......	518	74	68	4
11-20	6 51	12	......	0.7	5.9	17.0	26.8	31.3	34.1	42.1	45.0	43.3	35.4	31.5	22.0	11.4	3.1	......	349	52	36	7
21-31	6 39	9	......	1.4	11.7	24.8	43.4	52.8	61.9	69.9	68.5	58.7	52.6	41.1	28.4	12.6	1.8	......	530	82	82	2
Sept. 1-10	6 26	7	......	0.3	5.4	14.6	26.4	38.3	44.4	51.2	52.5	56.8	50.2	38.6	25.8	10.2	1.7	......	417	68	52	6
11-20	6 13	3	......	0.1	4.9	15.0	22.9	29.2	35.2	40.8	49.6	47.7	43.2	32.3	17.2	5.1	......	......	343	60	40	6
21-30	6 01	± 0	......	......	4.8	14.7	27.7	41.0	47.1	56.0	56.4	52.6	37.6	30.3	16.2	4.2	......	......	389	73	50	5
Oct. 1-10	5 48	− 3	......	......	2.8	13.6	24.4	37.6	43.2	45.4	48.6	45.4	36.7	27.4	13.4	1.4	......	......	340	69	71	3
11-20	5 36	− 6	......	......	1.4	11.3	22.4	34.1	40.7	44.5	42.0	37.2	27.7	17.4	6.5	0.7	......	......	286	63	51	5
21-31	5 23	− 7	......	......	0.9	8.4	19.1	31.9	34.8	43.7	45.6	38.7	27.5	15.4	3.6	0.1	......	......	270	64	63	5
Nov. 1-10	5 11	− 8	......	......	0.1	5.6	15.0	24.4	32.3	36.0	39.4	32.2	20.3	13.1	3.0	......	......	......	221	57	53	5
11-20	5 01	− 7	......	......	......	3.3	10.4	19.2	28.7	35.0	34.9	32.8	25.6	13.4	2.5	......	......	......	206	57	72	3
21-30	4 52	− 4	......	......	......	3.2	11.5	17.7	27.4	31.5	33.6	28.3	22.2	9.9	1.1	......	......	......	188	56	75	4
Dec. 1-10	4 47	− 1	......	......	......	1.5	11.2	21.2	28.4	32.9	33.5	30.6	22.2	10.0	0.9	......	......	......	192	61	86	3
11-20	4 43	4	......	......	......	0.2	6.6	11.9	21.0	27.0	25.1	20.9	15.4	4.9	0.2	......	......	......	133	44	55	5
21-31	4 43	8	......	......	......	0.9	7.4	17.9	27.0	32.7	36.5	30.6	21.9	11.5	2.6	......	......	......	189	61	65	5
1910.																						
Jan. 1-10	4 46	14	......	......	......	0.5	6.4	14.9	25.4	29.1	28.3	24.8	19.1	11.4	2.7	......	......	......	163	51	56	6
11-20	4 52	18	......	......	......	0.9	6.0	15.4	21.5	25.5	28.4	26.2	20.0	11.3	2.5	......	......	......	158	47	56	6
21-31	5 01	21	......	......	......	0.5	4.4	12.1	19.6	19.4	20.4	18.3	15.6	10.6	3.8	0.1	......	......	125	35	28	8
Feb. 1-10	5 12	22	......	......	......	2.2	11.7	22.9	35.6	42.8	46.3	40.5	30.6	19.5	7.1	0.7	......	......	260	67	71	4
11-20	5 23	22	......	......	......	3.8	15.3	28.2	36.8	41.8	43.9	39.8	30.6	18.2	7.2	0.6	......	......	266	60	67	5
21-28	5 34	21	......	......	......	5.0	13.2	23.9	38.5	43.2	39.9	37.7	34.2	20.0	10.9	2.7	......	......	269	53	54	6
Mar. 1-10	5 46	20	......	......	0.4	5.9	14.9	26.1	34.0	38.3	40.7	39.9	36.4	27.9	14.8	3.8	0.2	......	283	50	59	5
11-20	5 59	17	......	......	2.3	11.2	24.6	34.4	51.3	50.0	52.1	50.0	41.4	25.3	14.0	3.7	0.8	......	361	55	58	5
21-31	6 12	14	......	0.2	5.4	16.4	28.6	38.6	50.0	49.0	51.8	52.8	44.8	30.9	18.8	7.5	1.2	......	396	58	64	5
Apr. 1-10	6 25	11	......	0.6	6.3	18.6	31.9	42.5	46.8	47.6	52.9	50.5	44.8	34.4	19.7	8.7	1.3	......	407	57	60	4
11-20	6 37	8	......	1.0	9.5	22.6	42.8	53.4	55.1	60.6	59.5	47.4	42.4	29.2	20.8	10.6	2.2	......	457	63	64	5
21-30	6 49	6	......	1.6	10.5	25.5	38.4	50.3	56.0	61.5	64.5	60.6	59.7	46.5	32.1	17.0	3.9	......	529	71	70	4
May 1-10	7 00	5	......	2.6	14.1	30.9	41.2	52.5	57.7	62.5	62.8	53.4	48.6	39.5	28.3	16.1	4.6	0.2	515	69	71	5
11-20	7 10	4	......	3.6	14.3	27.8	40.7	51.0	55.8	62.1	64.7	61.4	47.7	39.1	22.5	14.3	4.7	0.5	510	68	63	6
21-31	7 18	5	......	2.5	11.0	21.8	33.0	37.6	42.8	50.2	48.1	44.8	41.1	35.4	25.6	16.1	5.4	0.8	416	55	44	6
June 1-10	7 24	6	......	1.3	6.0	12.5	23.1	31.4	39.2	47.9	50.1	47.2	37.4	35.9	25.9	15.4	5.3	0.4	379	50	42	7
11-20	7 27	8	0.2	5.0	18.0	33.6	47.8	60.9	65.5	68.5	65.8	68.3	64.2	48.4	38.4	21.5	8.5	1.5	616	82	83	3
21-30	7 27	11	0.2	3.5	13.5	28.4	41.2	50.2	56.4	56.8	58.7	57.7	49.5	40.0	27.8	16.9	6.1	0.8	507	68	61	4
July 1-10	7 24	12	......	2.7	10.5	25.7	40.8	49.6	51.3	51.7	47.9	49.2	44.7	36.3	27.0	13.9	6.4	0.4	458	62	46	4
11-20	7 19	14	......	3.0	14.8	30.3	44.4	58.7	67.0	71.5	74.9	71.2	59.6	48.0	35.0	21.4	8.3	0.5	609	85	70	2
21-31	7 11	14	......	1.2	9.9	22.4	37.7	48.5	51.6	55.0	62.5	60.4	54.0	47.0	29.2	17.4	5.1	......	502	72	70	4
Aug. 1-10	7 01	14	......	0.5	7.0	19.0	26.6	35.6	37.9	48.4	52.8	54.4	43.0	31.1	24.6	14.0	2.9	......	398	59	41	7
11-20	6 51	12	......	0.4	5.9	15.7	24.9	30.8	46.4	44.2	44.6	43.5	40.4	26.5	20.0	9.7	1.7	......	355	55	46	6
21-31	6 39	9	......	0.2	5.3	17.0	29.5	39.7	48.0	50.8	52.0	42.0	35.3	30.3	20.2	7.8	1.3	......	380	62	58	4
Sept. 1-10	6 26	7	......	......	3.2	13.6	26.1	41.4	49.8	49.4	54.4	50.2	41.4	31.0	16.5	6.2	0.3	......	384	67	59	4
11-20	6 13	3	......	......	3.4	15.0	27.7	40.9	47.4	52.1	51.9	46.2	40.4	29.5	14.5	4.5	......	......	373	70	68	4
21-30	6 01	± 0	......	......	3.0	14.9	28.8	39.6	46.4	49.3	48.6	43.3	34.1	22.5	12.0	2.4	......	......	345	70	64	4
Oct. 1-10	5 48	− 3	......	......	1.6	12.1	26.5	38.5	48.1	52.1	49.6	44.9	37.6	25.6	12.2	1.5	......	......	350	77	79	2
11-20	5 36	− 6	......	......	1.2	9.6	25.7	37.3	44.1	45.1	42.1	39.0	29.8	20.4	8.9	0.7	......	......	304	72	57	5
21-31	5 23	− 7	......	......	0.5	7.0	19.9	31.1	38.9	40.0	37.1	29.0	21.8	12.2	3.7	0.2	......	......	241	62	52	5
Nov. 1-10	5 11	− 8	......	......	0.1	4.9	15.6	27.8	37.1	41.0	36.7	26.6	21.3	10.7	1.8	......	......	......	224	62	44	6
11-20	5 01	− 7	......	......	......	4.3	11.8	21.9	30.1	32.7	32.7	28.4	17.7	9.5	1.5	......	......	......	191	57	56	5
21-30	4 52	− 4	......	......	......	2.3	9.3	19.4	27.4	32.4	30.0	25.7	18.2	8.7	1.5	......	......	......	175	55	51	5
Dec. 1-10	4 47	− 1	......	......	......	1.5	9.0	19.4	30.1	35.0	32.7	27.3	20.5	10.2	2.1	......	......	......	188	62	46	5
11-20	4 43	4	......	......	......	1.4	8.9	17.2	23.4	28.1	30.7	28.4	21.5	12.5	3.0	......	......	......	175	56	43	7
21-31	4 43	8																				
1911.																						
Jan. 1-10	4 46	14	......	......	......	1.4	10.2	21.5	25.4	33.6	33.8	27.7	22.6	14.5	5.7	0.1	......	......	196	61	54	5
11-20	4 52	18	......	......	......	1.0	5.7	13.3	22.7	25.1	26.4	25.4	22.4	16.1	6.0	0.6	......	......	165	49	22	8
21-31	5 01	21	......	......	......	1.7	10.7	20.3	28.7	33.4	36.4	34.5	27.3	19.3	9.1	0.9	......	......	222	63	46	6
Feb. 1-10	5 12	22	......	......	......	1.9	9.3	19.4	26.0	30.9	33.9	33.3	26.8	18.7	9.6	1.6	......	......	211	54	46	6
11-20	5 23	22	......	......	0.3	4.0	11.0	18.2	24.5	28.3	30.2	29.8	23.1	14.1	7.8	1.6	......	......	193	43	39	6
21-28	5 34	21	......	......	0.4	7.0	24.9	44.3	58.3	65.8	69.4	58.4	51.6	35.8	19.2	5.4	......	......	441	88	72	3
Mar. 1-10	5 46	20	......	......	1.0	10.1	22.0	36.8	45.4	48.1	52.5	51,6	40.9	32.9	19.9	5.8	......	......	367	65	63	5
11-20	5 59	17	......	......	1.5	10.2	22.4	35.5	45.1	49.3	51.1	46.1	40.2	28.3	15.0	5.1	0.3	......	350	57	42	6
21-31	6 12	14	......	......	5.1	20.9	36.1	56.3	63.9	65.5	62.4	55.9	43.3	31.3	18.1	7.3	0.6	......	467	71	67	4
Apr. 1-10	6 25	11	......	0.3	5.1	14.6	20.9	33.0	43.7	42.4	39.4	39.6	38.1	26.6	18.1	6.8	1.0	......	330	48	40	6
11-20	6 37	8	......	0.7	7.1	16.8	31.4	43.0	47.7	47.0	52.2	46.8	43.1	37.6	23.6	9.7	1.8	......	408	57	54	5
21-30	6 49	6	......	1.9	10.4	22.6	38.1	52.4	62.8	66.8	66.9	62.1	52.6	42.8	27.8	11.5	2.2	......	521	71	53	5
May 1-10	7 00	5	0.1	3.5	15.0	34.3	48.9	59.2	65.9	71.0	69.0	64.7	57.7	41.9	31.0	14.4	3.1	0.1	580	78	68	4
11-20	7 10	4	0.1	3.3	14.4	30.2	46.9	62.7	71.6	73.8	75.1	69.8	60.5	48.9	33.1	15.0	3.9	0.2	609	81	88	2
21-31	7 18	5	0.1	4.0	16.0	31.0	48.9	61.6	70.7	76.0	79.8	74.7	63.2	47.6	34.1	16.3	4.6	0.5	629	83	80	3
June 1-10	7 24	6	0.8	6.9	11.5	24.4	38.8	46.9	53.9	58.8	59.8	56.1	50.8	39.9	28.0	13.1	2.8	0.2	493	65	54	6
11-20	7 27	8	0.0	3.5	12.9	21.6	38.7	54.5	61.8	65.4	62.9	59.2	45.5	30.9	21.9	16.2	6.2	0.6	502	66	46	6
21-30	7 27	11	0.1	3.6	16.2	29.3	45.8	57.7	67.3	75.0	77.2	74.6	62.9	48.9	31.2	19.2	6.9	0.9	617	82	70	4
July 1-10	7 24	12	0.0	3.4	16.0	31.9	46.1	58.1	64.2	71.1	65.9	63.1	59.5	48.0	28.8	17.1	6.8	1.6	582	78	70	4
11-20	7 19	14	0.1	3.1	12.8	24.4	34.2	39.9	50.2	58.5	59.4	53.2	52.4	43.6	36.8	23.6	7.7	0.5	501	68	52	5
21-31	7 11	14	......	2.6	12.2	31.2	48.4	62.9	70.3	72.2	76.7	69.4	62.3	50.8	31.1	16.8	6.3	0.4	614	86	76	4
Aug. 1-10	7 01	14	......	1.8	10.3	22.0	39.0	46.4	56.0	66.3	63.4	66.4	59.8	41.6	28.5	15.8	4.6	0.1	522	74	62	5
11-20	6 51	12	......	0.7	9.9	23.7	36.8	45.7	54.2	64.4	64.2	60.1	54.2	45.4	27.4	13.7	3.1	......	503	74	60	5
21-31	6 39	9	......	0.4	6.0	19.4	33.4	48.3	53.1	58.0	57.7	44.4	41.4	30.3	19.7	8.9	1.5	......	422	65	51	6
Sept. 1-10	6 26	7	......	0.0	3.9	15.0	29.7	49.8	59.0	64.8	65.2	57.3	46.2	32.5	21.3	7.6	0.9	......	451	74	58	4
11-20	6 13	3	......	0.3	3.4	13.6	23.7	32.1	42.7	44.1	44.5	45.7	44.8	37.3	20.7	7.9	0.4	......	361	63	47	6
21-30	6 01	± 0	......	......	2.0	9.6	19.9	32.5	43.2	50.6	55.1	47.5	37.0	26.2	16.0	3.7	......	......	343	64	31	7
Oct. 1-10	5 48	− 3	......	......	2.1	10.0	20.6	34.3	44.5	46.3	44.6	41.9	30.9	18.0	9.3	1.8	......	......	304	61	44	6
11-20	5 36	− 6	......	......	0.8	6.4	18.0	24.6	35.5	41.4	43.6	39.1	30.4	22.3	9.7	1.5	......	......	273	60	50	6
21-31	5 23	− 7	......	......	0.8	6.6	18.0	30.4	42.4	42.9	44.2	40.3	30.6	18.0	6.9	0.3	......	......	282	67	60	5
Nov. 1-10	5 11	− 8	......	......	0.1	4.3	15.0	27.9	32.9	34.5	36.8	32.1	23.4	14.3	4.3	......	......	......	226	58	46	5
11-20	5 01	− 7	......	......	0.1	4.5	16.9	26.0	39.1	43.6	42.3	35.5	25.7	14.0	3.5	......	......	......	251	69	55	5
21-30	4 52	− 4	......	......	......	2.0	13.7	22.8	29.8	34.3	31.6	26.6	19.1	9.8	2.6	......	......	......	192	57	43	6
Dec. 1-10	4 47	− 1	......	......	......	3.0	14.0	26.1	36.0	38.4	39.1	33.8	28.3	16.8	4.5	......	......	......	240	76	68	4
11-20	4 43	4	......	......	......	1.2	7.7	15.5	20.6	20.5	22.1	19.2	15.7	9.6	1.8	......	......	......	134	44	20	8
21-31	4 43	8	......	......	......	0.5	4.9	10.7	16.7	17.6	18.9	14.2	12.7	7.9	2.1	......	......	......	106	34	17	8
1912.																						
Jan. 1-10	4 46	14	......	......	......	0.9	9.7	20.9	29.2	35.1	35.5	34.4	23.7	15.5	5.2	......	......	......	210	65	44	6
11-20	4 52	18	......	......	......	0.7	4.0	9.7	18.5	26.0	30.1	27.8	19.7	13.3	6.2	0.1	......	......	156	47	20	8
21-31	5 01	21	......	......	......	1.1	7.3	14.8	24.9	33.2	36.5	32.4	24.6	18.4	8.3	0.8	......	......	202	57	42	7
Feb. 1-10	5 12	22	......	......	......	2.6	15.1	34.3	44.7	49.6	52.3	47.2	38.7	26.4	13.8	1.4	......	......	326	84	63	4
11-20	5 23	22	......	......	......	2.6	12.3	25.6	34.1	35.7	36.7	33.2	25.8	19.2	10.1	1.9	......	......	237	53	41	6
21-29	5 34	21	......	......	0.2	4.8	16.2	26.5	34.7	43.5	42.8	35.7	25.9	21.0	16.5	2.8	......	......	271	54	45	6
Mar. 1-10	5 46	20	......	......	0.1	5.2	15.7	26.5	35.8	39.3	41.4	38.6	32.9	24.1	11.9	3.6	......	......	275	49	38	6
11-20	5 59	17	......	......	1.2	9.4	20.5	32.9	44.9	49.5	51.2	44.7	35.6	27.3	13.5	4.3	0.1	......	335	54	51	5
21-31	6 12	14	......	......	2.1	11.3	22.5	36.6	47.3	52.7	55.1	48.8	35.9	27.9	14.0	5.3	0.3	......	360	55	53	5
Apr. 1-10	6 25	11	......	......	4.6	18.4	31.8	39.7	48.5	52.9	54.5	46.3	41.6	31.1	18.0	7.1	1.1	......	396	58	55	5
11-20	6 37	8	......	0.1	6.1	16.3	23.9	26.8	35.3	39.1	37.4	41.0	36.4	24.0	19.3	9.3	1.0	......	316	44	30	7

TABLE 2.—*Solar and sky radiation, expressed in gram-calories per square centimeter of horizontal surface, at Washington, D. C.*

[American University, District of Columbia, Lat. 38° 56' W., Long. 77° 05' N. Altitude, 137 meters.]

Decade.	Mean solar h. s. at sunrise and sunset.	Decade average during hours ending (apparent time)— A. M. 5	6	7	8	9	10	11	Noon.	P. M. 1	2	3	4	5	6	7	8	Daily average.	Per cent of possible radiation.	Per cent of possible sunshine.	Mean daily cloudiness.
1914.	*H. m.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	*Gr.-c.*	%	%	*0-10*
Nov. 1-10	5 11			0.2	3.5	16.4	31.9	40.9	45.2	45.5	40.9	30.4	15.3	4.2	0.6			275	71	86	2
11-20	5 01				2.2	10.6	21.7	28.5	34.8	31.0	29.0	22.4	12.6	3.3	0.3			196	54	60	5
21-30	4 52				1.9	11.5	21.9	29.4	33.8	33.0	28.3	21.2	11.5	2.3	0.1			195	58	57	6
Dec. 1-10	4 47				0.5	3.2	7.5	11.7	12.8	15.3	11.8	8.5	4.6	0.9				77	24	8	10
11-20	4 43				1.3	9.1	19.0	24.6	28.1	26.9	23.6	17.1	7.2	1.6				159	52	58	5
21-31	4 43				1.1	7.3	14.6	19.6	23.1	26.9	24.0	16.3	7.4	1.2				142	46	44	7
1915.																					
Jan. 1-10	4 46				1.4	9.6	19.8	29.5	34.7	33.0	31.1	21.3	8.7	1.4				190	59	75	3
11-20	4 52				1.4	6.1	13.4	18.0	18.6	17.7	16.3	12.9	6.1	1.9	0.1			113	34	39	7
21-31	5 01				1.9	8.4	17.5	24.1	25.8	24.5	23.9	13.7	7.8	2.0				146	41	40	7
Feb. 1-10	5 12			0.2	3.3	10.2	17.4	23.4	26.8	25.9	20.9	17.3	10.7	3.0	0.3			159	41	38	7
11-20	5 23			0.3	5.1	15.2	26.3	36.4	37.6	36.2	31.2	23.4	15.5	4.6	0.4			232	52	59	6
21-28	5 34			0.6	8.3	22.2	29.8	42.0	47.8	51.2	45.8	32.6	19.4	6.8	0.7			307	61	78	4

TABLE 3.—*Radiation extremes at Washington, D. C.*

[Gram-calories per square centimeter of horizontal surface.]

Decade.	Sun's mean zenith distance at noon. °	'	Maximum. Per minute.	Maximum. Per hour.	Maximum. Per day.	Minimum. Per day.
1909.	°	'	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
July 24-31	19	42	1.54	82.2	666	416
Aug. 1-10	22	01	1.55	80.6	599	413
11-20	24	57	1.52	81.4	636	142
21-31	28	26	1.41	80.3	641	280
Sept. 1-10	32	13	1.34	75.6	602	166
11-20	36	00	1.37	67.9	482	134
21-30	39	54	1.38	73.2	507	227
Oct. 1-10	43	46	1.25	64.4	441	118
11-20	47	32	1.14	59.7	402	104
21-31	51	17	1.05	60.4	390	71
Nov. 1-10	54	41	0.89	50.8	304	30
11-20	57	28	0.88	46.2	270	98
21-30	59	42	0.94	43.7	247	28
Dec. 1-10	61	18	0.78	43.7	245	27
11-20	62	10	0.72	35.9	187	19
21-31	62	17	0.88	48.8	278	39
1910.						
Jan. 1-10	61	29	0.81	47.2	286	17
11-20	59	59	0.83	47.4	284	22
21-31	57	41	1.00	47.1	276	17
Feb. 1-10	54	46	1.01	59.5	354	25
11-20	51	31	1.14	62.8	381	53
21-28	48	18	1.22	69.0	463	108
Mar. 1-10	44	54	1.15	68.5	477	52
11-20	40	59				
21-31	36	46				
Apr. 1-10	32	48	1.39	81.1	617	154
11-20	29	06	1.45	81.7	649	55
21-30	25	41	1.69	84.9	670	198
May 1-10	22	38	1.57	88.9	749	298
11-20	20	02	1.68	91.8	752	140
21-31	17	47	1.77	87.5	726	318
June 1-10	16	22	1.58	86.1	752	58
11-20	15	36	1.64	76.4	580	184
21-30	15	31	1.55	85.5	711	451
July 1-10	16	08	1.51	87.1	710	224
11-20	17	24	1.51	86.9	657	168
21-31	19	23	1.42	85.6	736	462
Aug. 1-10	21	57	1.48	80.6	672	104
11-20	24	53	1.45	74.8	608	164
21-31	28	21	1.36	72.1	544	108
Sept. 1-10	32	07	1.29	72.3	536	114
11-20	35	55	1.29	73.1	550	164
21-30	39	47	1.23	65.2	474	198
Oct. 1-10	43	42	1.14	64.7	481	60
11-20	47	27	1.09	63.0	438	143
21-31	51	17	1.30	63.0	397	186
Nov. 1-10	54	36	1.27	60.2	376	72
11-20	57	24	1.13	56.9	346	93
21-30	59	40	0.97	56.2	342	27
Dec. 1-10	61	16	1.13	57.1	284	19
11-20	62	09	0.89	47.7	277	108
21-31	62	15	0.81	47.5	283	71
1911.						
Jan. 1-10	61	30	1.02	54.0	340	29
11-20	60	01	1.21	54.9	297	41
21-31	57	44	1.00	57.3	346	36
Feb. 1-10	54	50	1.22	63.6	407	33
11-20	51	36	1.20	67.2	424	16
21-28	48	24	1.25	73.7	504	294

Decade.	Sun's mean zenith distance at noon. °	'	Maximum. Per minute.	Maximum. Per hour.	Maximum. Per day.	Minimum. per day.
1911.	°	'	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr-cal.*
Mar. 1-10	45	00	1.36	77.0	546	166
11-20	41	05	1.60	87.4	642	45
21-31	36	51	1.58	86.7	642	320
Apr. 1-10	32	53	1.55	90.3	690	54
11-20	29	12	1.75	88.6	693	94
21-30	25	46	1.71	90.3	736	60
May 1-10	22	42	1.70	87.5	712	237
11-20	20	05	1.55	81.7	675	552
21-31	17	49	1.60	85.8	740	416
June 1-10	16	23	1.62	90.8	774	112
11-20	15	36	1.59	90.0	699	188
21-30	15	31	1.65	87.4	766	357
July 1-10	16	06	1.71	85.0	743	335
11-20	17	22	1.56	85.4	618	329
21-31	19	20	1.62	87.8	722	331
Aug. 1-10	21	53	1.66	86.6	693	285
11-20	24	48	1.70	84.2	679	336
21-31	28	16	1.60	82.0	641	56
Sept. 1-10	32	02	1.43	80.9	627	217
11-20	35	49	1.41	77.0	564	165
21-30	39	42	1.33	73.4	536	239
Oct. 1-10	43	34	1.31	72.1	485	73
11-20	47	22	1.27	71.0	491	107
21-31	51	13	1.14	66.1	417	85
Nov. 1-10	54	32	1.10	56.0	354	37
11-20	57	20	1.04	60.0	365	44
21-30	59	37	1.06	54.8	333	11
Dec. 1-10	61	14	0.92	52.0	317	148
11-20	62	09	0.88	42.0	256	19
21-31	62	15	1.13	52.8	317	16
1912.						
Jan. 1-10	61	32	1.05	56.9	358	51
11-20	60	04	0.83	42.6	217	84
21-31	57	48	1.04	54.2	343	41
Feb. 1-10	54	55	1.12	63.6	379	185
11-20	51	41	1.06	61.9	417	65
21-29	48	18	1.29	71.2	457	23
Mar. 1-10	44	42	1.29	67.7	467	90
11-20	40	47	1.38	80.3	567	43
21-31	36	33	1.43	78.1	559	69
Apr. 1-10	32	36	1.46	77.8	542	118
11-20	28	55	1.42	77.8	570	59
1914.						
Nov. 1-10	54	39	1.07	51.6	301	172
11-20	57	27	0.94	46.5	268	19
21-30	59	42	0.83	47.0	267	122
Dec. 1-10	61	18	0.64	33.8	145	20
11-20	62	11	0.90	46.3	260	34
21-31	62	17	0.88	48.6	264	42
1915.						
Jan. 1-10	61	32	0.76	43.9	242	92
11-20	61	03	0.74	43.1	244	24
21-31	57	46	0.86	50.7	287	49
Feb. 1-10	54	52	1.04	56.2	340	28
11-20	51	38	1.10	64.1	399	77
21-28	48	25	1.21	70.4	448	62

TABLE 4.—*Daily normals and departures of solar and sky radiation.*

[Gram-calories per square centimeter of horizontal surface.]

Month and day.	Daily normal.	Daily departures.						Total excess or deficiency since 1st of month.					
		Washington, D. C.			Mount Weather, Va.		Washington.	Washington, D. C.			Mount Weather, Va.		Washington.
		1910	1911	1912	1913	1914	1915	1910	1911	1912	1913	1914	1915
	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
Jan. 1	164	*− 12	−135	− 8	66	30	41	− 12	−135	− 8	66	30	41
2	164	− 63	−124	33	61	− 58	− 1	− 75	−259	25	127	− 28	40
3	164	− 60	−133	− 91	−106	−152	53	−135	−392	− 66	21	−180	93
4	164	83	* 108	18	79	−120	− 67	− 52	−284	− 48	100	−300	26
5	164	−147	63	64	− 15	− 98	55	−199	−221	16	85	−398	81
6	165	−111	122	61	− 17	100	− 73	−310	− 99	77	68	−298	8
7	165	4	117	132	−119	− 67	72	−306	18	209	− 51	−365	80
8	166	81	* 41	−115	−107	29	76	−225	59	94	−158	−336	156
9	166	84	83	192	96	− 72	41	−141	142	286	− 62	−408	197
10	167	119	173	166	− 12	34	59	− 22	315	452	− 74	−374	256
11	167	22	− 35	− 31	− 18	34	87	0	280	421	− 92	−340	169
12	168	− 37	−127	− 84	−118	92	144	− 37	153	337	−210	−248	25
13	168	−111	− 98	*− 6	81	* 84	76	−148	55	331	−129	−164	101
14	169	−147	− 37	†− 16	54	* 119	*− 86	−295	18	315	− 75	− 45	15
15	170	99	− 77	†− 74	60	16	61	−196	− 59	241	− 15	− 29	76
16	172	† 112	125	†− 1	− 74	− 79	48	− 84	66	240	− 89	−108	124
17	174	− 79	− 77	* 43	− 24	− 71	−134	−163	− 11	283	−113	−179	− 10
18	176	− 84	90	− 5	− 65	30	−144	−247	79	278	−178	−149	− 154
19	178	38	116	11	65	− 42	−102	−209	195	289	−113	−191	− 256
20	180	43	44	4	− 16	− 18	− 84	−166	239	293	−129	−209	− 340
Decade departure								−144	− 76	−159	− 55	165	− 596
21	182	−165	− 70	161	33	63	2	−331	169	454	− 96	−146	− 338
22	184	− 14	−148	113	96	− 39	− 68	−345	21	567	0	−185	− 406
23	186	† 80	160	85	− 91	72	−125	−265	181	652	− 91	−113	− 531
24	189	−108	150	49	−161	−110	−128	−373	331	701	−252	−223	− 659
25	191	85	133	19	57	50	− 65	−288	464	720	−195	−173	− 724
26	194	− 71	− 50	−140	87	93	65	−359	414	580	−108	− 80	− 659
27	196	−148	34	4	−169	21	− 46	−507	448	584	−277	− 59	− 705
28	198	−137	147	8	48	13	−128	−644	595	502	−229	− 46	− 833
29	200	−110	−137	−159	−126	89	87	−754	458	433	−355	43	− 746
30	203	*− 15	139	− 96	89	− 29	37	−769	597	337	−266	14	− 709
31	205	−146	− 39	54	− 12	− 93	−156	−915	558	391	−278	− 79	− 865
Decade departure								−749	319	98	−149	130	− 525
Total excess or deficiency since first of year								−915	558	391	−278	− 79	− 865
Feb. 1	208	* 92	−126	78	115	128	−180	92	−126	78	115	128	− 180
2	212	98	− 76	− 27	107	134	−163	190	−202	51	222	262	− 343
3	216	−107	160	54	−184	− 4	−167	83	− 42	105	38	258	− 510
4	220	118	39	159	− 49	95	42	201	− 3	264	87	353	− 468
5	224	60	120	124	117	−132	−157	261	117	388	204	221	− 625
6	228	† 42	−185	148	128	−204	− 75	303	− 68	536	332	17	− 700
7	232	122	124	129	112	104	*−156	425	56	665	444	121	− 856
8	236	22	−203	108	− 14	139	− 1	449	−145	773	430	260	− 857
9	240	*−215	−163	93	53	165	94	232	−310	866	483	425	− 763
10	244	109	163	134	54	−139	96	341	−147	1,000	537	286	− 667
11	248	−195	157	136	−124	69	74	146	10	1,136	413	355	− 593
12	252	30	172	− 57	103	95	−165	176	182	1,079	516	450	− 758
13	256	24	† 66	161	123	−161	−154	200	248	1,240	639	289	− 912
14	260	101	− 98	25	102	* 107	−141	301	150	1,265	741	396	−1,053
15	263	†− 62	−238	−198	90	* 141	−186	239	− 88	1,067	831	537	−1,239
16	267	55	−106	− 26	−102	*80	− 78	294	−194	1,041	729	617	−1,317
17	270	− 75	−148	†− 3	−119	* 6	5	219	−342	1,038	610	623	−1,312
18	274	104	−258	−206	104	−140	125	323	−600	832	714	483	−1,187
19	277	104	−114	36	52	−206	107	427	−714	868	766	277	−1,080
20	280	†− 70	−150	−144	−150	−152	89	357	−864	724	616	125	− 991
Decade departure								16	−717	−276	79	−161	− 324
21	284	*−176	144	−261	−120	193	75	181	−720	463	496	318	− 916
22	287	15	170	95	−170	− 48	67	196	−550	558	326	270	− 849
23	290	*− 11	† 214	167	61	−205	− 35	185	−336	725	387	65	− 884
24	293	−113	†79	− 44	− 9	224	−231	72	−257	681	378	289	−1,115
25	296	167	† 207	− 48	50	* 139	− 96	239	− 50	633	428	428	−1,211
26	299	*63	† 198	−247	*− 69	185	128	302	148	386	359	613	−1,083
27	302	*26	† 168	52	†−227	113	50	328	316	438	132	726	−1,033
28	305	†−174	†− 11	* 96	* 56	− 74	143	154	305	534	188	652	− 890
29	306			− 34						500			
Decade departure								−203	1,169	−224	−428	527	101
Total excess or deficiency since first of year								−761	863	891	− 90	573	−1,755

* Partly estimated from sunshine record. † Estimated from sunshine record.

TABLE 4.—*Daily normals and departures of solar and sky radiation*—Continued.

Month and day.	Daily normals.	Daily departures.					Total excess or deficiency since first of month.				
		Washington, D. C.			Mount Weather, Va.		Washington, D. C.			Mount Weather, Va.	
		1910	1911	1912	1913	1914	1910	1911	1912	1913	1914
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Mar. 1	308	−191	†45	*117	−143	−165	−191	45	117	−143	−165
2	310	−171	−1	61	130	−48	−362	44	178	−13	−213
3	313	−112	172	− 44	94	*161	−474	216	134	81	−52
4	316	72	−150	−191	−144	95	−402	66	−57	−63	43
5	318	21	228	54	105	−245	−381	294	−3	42	−202
6	321	57	*−57	−195	67	−225	−324	237	−198	109	−427
7	323	154	−142	61	156	87	−170	95	−137	265	−340
8	325	69	17	−203	−21	59	−101	112	−340	244	−281
9	328	18	211	−238	1	88	−83	323	−578	245	−193
10	330	−278	154	137	−239	180	−361	477	−441	6	−13
11	332		221	76	−57	−242		698	−365	−51	−255
12	335		*61	−292	42	243		759	−657	−9	−12
13	337		−229	−84	−285	108		530	−741	−294	96
14	339		−232	60	−218	94		298	−681	−512	190
15	341		109	−294	−187	*125		407	−975	−699	315
16	343		299	49	−87	*46		706	−926	−786	361
17	345		191	222	186	65		897	−704	−600	426
18	347		−214	95	175	−43		683	−609	−425	383
19	350		−305	90	95	−92		378	−519	−330	291
20	352		179	8	−7	29		557	−511	−337	320
Decade departure								80	−70	−331	333
21	354		233	*−255	−196	*121		790	−766	−533	441
22	356		74	11	166	57		864	−755	−367	498
23	358		108	5	22	54		972	−750	−345	552
24	360		*282	−291	−96	*178		1,254	−1,041	−441	730
25	362		*202	89	−166	149		1,456	−952	−607	879
26	364		−19	166	−270	−31		1,437	−786	−877	848
27	366		29	38	74	−5		1,466	−748	−803	843
28	368		157	−83	201	*−120		1,623	−831	−602	723
29	370	2	−50	−89	166	−266	2	1,573	−920	−436	457
30	372	−39	*17	179	−62	−212	−37	1,590	−741	−498	245
31	374	3	98	185	70	11	−34	1,688	−556	−428	256
Decade departure								1,131	−45	−91	−64
Total excess or deficiency since first of year								2,551	335	−518	829
Apr. 1	376	37	*107	33	136	−283	37	107	33	136	−283
2	378	111	274	−194	−63	−257	148	381	−161	73	−540
3	381	*−227	−321	36	98	−140	−79	60	−125	171	−680
4	383	*−97	−329	159	−105	23	−176	−269	34	66	−657
5	385	34	−292	96	248	*71	−142	−561	130	314	−586
6	388	−44	214	36	−27	206	−186	−347	166	287	−380
7	390	−141	−215	−172	225	55	−327	−562	−6	512	−325
8	393	224	−283	90	207	−343	−103	−845	84	719	−668
9	396	−2	−20	139	54	143	−105	−865	223	773	−525
10	398	197	292	−135	−116	245	92	−573	88	657	−280
11	401	121	210	169	−335	77	213	−363	257	302	−208
12	404	−246	89	132	−330	235	−33	−274	389	−28	32
13	407	223	45	−197	−256	239	190	−229	192	−284	271
14	410	239	−316	−207	−345	−53	429	−545	−15	−629	218
15	413	129	−128	19	−301	−339	558	−673	4	−930	−121
16	418	69	152	−104	−147	−358	627	−521	−100	−1,077	−479
17	423	−368	33	*−364	*238	*85	259	−488	−464	−839	−394
18	428	−31	*265	−317	156	*151	228	−223	−781	−683	−243
19	433	−184	−281	−129	21	126	44	−504	−910	−662	−117
20	438	−60	−159	−16	267	−327	−16	−663	−926	−395	−444
Decade departure							−108	−90	−1,014	−1,052	−164
21	443	−244	*104		279	250	−260	−559		−116	−194
22	448	222	−388		*192	183	−38	−947		76	−11
23	453	−24	−91		119	73	−62	−1,038		195	62
24	458	−260	89		97	−17	−322	−949		292	45
25	463	54	273		77	−383	−268	−676		369	−338
26	468	149	232		−10	−85	−119	−444		350	−423
27	473	−91	174		−377	158	−210	−270		−18	−265
28	478	82	117		−102	122	−128	−153		−120	−143
29	483	−103	146		*−191	−56	−231	−7		−311	−199
30	488	133	−100		208	−169	−98	−107		−103	−368
Decade departure							−82	556		292	76
Total excess or deficiency since first of year							−859	2,444		−641	461

* Partly estimated from sunshine record. † Estimated from sunshine record.

TABLE 4.—*Daily normals and departures of solar and sky radiation.*

[Gram-calories per square centimeter of horizontal surface.]

Month and day.	Daily normal.	Daily departures. Washington, D. C. 1910	Daily departures. Washington, D. C. 1911	Daily departures. Washington, D. C. 1912	Daily departures. Mount Weather, Va. 1913	Daily departures. Mount Weather, Va. 1914	Daily departures. Washington. 1915	Total excess or deficiency since 1st of month. Washington, D. C. 1910	Total excess or deficiency since 1st of month. Washington, D. C. 1911	Total excess or deficiency since 1st of month. Washington, D. C. 1912	Total excess or deficiency since 1st of month. Mount Weather, Va. 1913	Total excess or deficiency since 1st of month. Mount Weather, Va. 1914	Total excess or deficiency since 1st of month. Washington. 1915
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Jan. 1	164	*− 12	−135	− 8	66	30	41	− 12	−135	− 8	66	30	41
2	164	− 63	−124	33	61	− 58	− 1	− 75	−259	25	127	− 28	40
3	164	− 60	−133	− 91	−106	−152	53	−135	−392	− 66	21	−180	93
4	164	83	*108	18	79	−120	− 67	− 52	−284	− 48	100	−300	26
5	164	−147	63	64	− 15	− 98	55	−199	−221	16	85	−398	81
6	165	−111	122	61	− 17	100	− 73	−310	− 99	77	68	−298	8
7	165	4	117	132	−119	− 67	72	−306	18	209	− 51	−365	80
8	166	81	*41	−115	−107	29	76	−225	59	94	−158	−336	156
9	166	84	83	192	96	− 72	41	−141	142	286	− 62	−408	197
10	167	119	173	166	− 12	34	50	− 22	315	452	− 74	−374	256
11	167	22	− 35	− 31	− 18	34	87	0	280	421	− 92	−340	169
12	168	− 37	−127	− 84	−118	92	144	− 37	153	337	−210	−248	25
13	168	−111	− 98	*− 6	81	*84	76	−148	55	331	−129	−164	101
14	169	−147	− 37	†− 16	54	*119	*− 86	−295	18	315	− 75	− 45	15
15	170	99	− 77	†− 74	60	16	61	−196	− 59	241	− 15	− 29	76
16	172	†112	125	†− 1	− 74	− 79	48	− 84	66	240	− 89	−108	124
17	174	− 79	− 77	*43	− 24	− 71	−134	−163	− 11	283	−113	−179	− 10
18	176	− 84	90	− 5	− 65	30	−144	−247	79	278	−178	−149	− 154
19	178	38	116	11	65	− 42	−102	−209	195	289	−113	−191	− 256
20	180	43	44	4	− 16	− 18	− 84	−166	239	203	−129	−209	− 340
Decade departure								−144	− 76	−159	− 55	165	− 596
21	182	−165	− 70	161	33	63	2	−331	169	454	− 96	−146	− 338
22	184	− 14	−148	113	96	− 39	− 68	−345	21	567	0	−185	− 406
23	186	†80	160	85	− 91	72	−125	−265	181	652	− 91	−113	− 531
24	189	−108	150	49	−161	−110	−128	−373	331	701	−252	−223	− 659
25	191	85	133	19	57	50	− 65	−288	464	720	−195	−173	− 724
26	194	− 71	− 50	−140	87	93	65	−359	414	580	−108	− 80	− 659
27	196	−148	34	4	−169	21	− 46	−507	448	584	−277	− 59	− 705
28	198	−137	147	8	48	13	−128	−644	595	592	−229	− 46	− 833
29	200	−110	−137	−159	−126	89	87	−754	458	433	−355	43	− 746
30	203	*− 15	139	− 96	89	− 29	37	−769	597	337	−266	14	− 709
31	205	−146	− 39	54	− 12	− 93	−156	−915	558	391	−278	− 79	− 865
Decade departure								−749	319	98	−149	130	− 525
Total excess or deficiency since first of year								−915	558	391	−278	− 79	− 865
Feb. 1	208	*92	−126	78	115	128	−180	92	−126	78	115	128	− 180
2	212	98	− 76	− 27	107	134	−163	190	−202	51	222	262	− 343
3	216	−107	160	54	−184	− 4	−167	83	− 42	105	38	258	− 510
4	220	118	39	150	− 49	95	42	201	− 3	264	87	353	− 468
5	224	60	120	124	117	−132	−157	261	117	388	204	221	− 625
6	228	†42	−185	148	128	−204	− 75	303	− 68	536	332	17	− 700
7	232	122	124	129	112	104	*−156	425	56	665	444	121	− 856
8	236	22	−203	108	− 14	139	− 1	449	−145	773	430	260	− 857
9	240	*−215	−163	93	53	165	94	232	−310	866	483	425	− 763
10	244	109	163	134	54	−139	96	341	−147	1,000	537	286	− 667
11	248	−195	157	136	−124	69	74	146	10	1,136	413	355	− 593
12	252	30	172	− 57	103	95	−165	176	182	1,079	516	450	− 758
13	256	24	†66	161	123	−161	−154	200	248	1,240	639	289	− 912
14	260	101	− 98	25	102	*107	−141	301	150	1,265	741	396	−1,053
15	263	†− 62	−238	−198	90	*141	−186	239	− 88	1,067	831	537	−1,239
16	267	55	−106	− 26	−102	*80	− 78	204	−194	1,041	729	617	−1,317
17	270	− 75	−148	†− 3	−119	*6	5	219	−342	1,038	610	623	−1,312
18	274	104	−258	−206	104	−140	125	323	−600	832	714	483	−1,187
19	277	104	−114	36	52	−206	107	427	−714	868	766	277	−1,080
20	280	†− 70	−150	−144	−150	−152	89	357	−864	724	616	125	− 991
Decade departure								16	−717	−276	79	−161	− 324
21	284	*−176	144	−261	−120	193	75	181	−720	463	496	318	− 916
22	287	15	170	95	−170	− 48	67	196	−550	558	326	270	− 849
23	290	*− 11	†214	167	61	−205	− 35	185	−336	725	387	65	− 884
24	293	−113	†79	− 44	− 9	224	−231	72	−257	681	378	289	−1,115
25	296	167	†207	− 48	50	*139	− 96	239	− 50	633	428	428	−1,211
26	299	*63	†198	−247	*− 69	185	128	302	148	386	359	613	−1,083
27	302	*26	†108	52	†−227	113	50	328	316	438	132	726	−1,033
28	305	†−174	†− 11	*96	*56	− 74	143	154	305	534	188	652	− 890
29	306			− 34						500			
Decade departure								−203	1,169	−224	−428	527	101
Total excess or deficiency since first of year								−761	863	891	− 90	573	−1,755

* Partly estimated from sunshine record. † Estimated from sunshine record.

TABLE 4.—*Daily normals and departures of solar and sky radiation*—Continued.

Month and day.	Daily normals.	Daily departures.					Total excess or deficiency since first of month.				
		Washington, D. C.			Mount Weather, Va.		Washington, D. C.			Mount Weather, Va.	
		1910	1911	1912	1913	1914	1910	1911	1912	1913	1914
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Mar. 1	308	−191	†45	*117	−143	−165	−191	45	117	−143	−165
2	310	−171	−1	61	130	−48	−362	44	178	−13	−213
3	313	−112	172	− 44	94	*161	−474	216	134	81	−52
4	316	72	−150	−191	−144	95	−402	66	−57	−63	43
5	318	21	228	54	105	−245	−381	294	−3	42	−202
6	321	57	*−57	−195	67	−225	−324	237	−198	109	−427
7	323	154	−142	61	156	87	−170	95	−137	265	−340
8	325	69	17	−203	−21	59	−101	112	−340	244	−281
9	328	18	211	−238	1	88	−83	323	−578	245	−193
10	330	−278	154	137	−239	180	−361	477	−441	6	−13
11	332		221	76	−57	−242		698	−365	−51	−255
12	335		*61	−292	42	243		759	−657	−9	−12
13	337		−229	−84	−285	108		530	−741	−294	96
14	339		−232	60	−218	94		298	−681	−512	190
15	341		109	−294	−187	*125		407	−975	−699	315
16	343		299	49	−87	*46		706	−926	−786	361
17	345		191	222	186	65		897	−704	−600	426
18	347		−214	95	175	−43		683	−609	−425	383
19	350		−305	90	95	−92		378	−519	−330	291
20	352		179	8	−7	29		557	−511	−337	320
Decade departure								80	−70	−331	333
21	354		233	*−255	−196	*121		790	−766	−533	441
22	356		74	11	166	57		864	−755	−367	498
23	358		108	5	22	54		972	−750	−345	552
24	360		*282	−291	−96	*178		1,254	−1,041	−441	730
25	362		*202	89	−166	149		1,456	−952	−607	879
26	364		−19	166	−270	−31		1,437	−786	−877	848
27	366		29	38	74	−5		1,466	−748	−803	843
28	368		157	−83	201	*−120		1,623	−831	−602	723
29	370	2	−50	−89	166	−266	2	1,573	−920	−436	457
30	372	−39	*17	179	−62	−212	−37	1,590	−741	−498	245
31	374	3	98	185	70	11	−34	1,688	−556	−428	256
Decade departure								1,131	−45	−91	−64
Total excess or deficiency since first of year								2,551	335	−518	829
Apr. 1	376	37	*107	33	136	−283	37	107	33	136	−283
2	378	111	274	−194	−63	−257	148	381	−161	73	−540
3	381	*−227	−321	36	98	−140	−79	60	−125	171	−680
4	383	*−97	−329	159	−105	23	−176	−269	34	66	−657
5	385	34	−292	96	248	*71	−142	−561	130	314	−586
6	388	−44	214	36	−27	206	−186	−347	166	287	−380
7	390	−141	−215	−172	225	55	−327	−562	−6	512	−325
8	393	224	−283	90	207	−343	−103	−845	84	719	−668
9	396	−2	−20	139	54	143	−105	−865	223	773	−525
10	398	197	292	−135	−116	245	92	−573	88	657	−280
11	401	121	210	169	−335	77	213	−363	257	302	−203
12	404	−246	89	132	−330	235	−33	−274	380	−28	32
13	407	223	45	−197	−256	239	190	−229	192	−284	271
14	410	239	−316	−207	−345	−53	429	−545	−15	−629	218
15	413	129	−128	19	−301	−339	558	−673	4	−930	−121
16	418	69	152	−104	−147	−358	627	−521	−100	−1,077	−479
17	423	−368	33	*−364	*238	*85	259	−488	−464	−839	−394
18	428	−31	*265	−317	156	*151	228	−223	−781	−683	−243
19	433	−184	−281	−129	21	126	44	−504	−910	−662	−117
20	438	−60	−159	−16	267	−327	−16	−663	−926	−395	−444
Decade departure							−108	−90	−1,014	−1,052	−164
21	443	−244	*104		279	250	−260	−559		−116	−194
22	448	222	−388		*192	183	−38	−947		76	−11
23	453	−24	−91		119	73	−62	−1,038		195	62
24	458	−260	89		97	−17	−322	−949		292	45
25	463	54	273		77	−383	−268	−676		369	−338
26	468	149	232		−10	−85	−119	−444		359	−423
27	473	−91	174		−377	158	−210	−270		−18	−265
28	478	82	117		−102	122	−128	−153		−120	−143
29	483	−103	146		*−191	−56	−231	−7		−311	−199
30	488	133	−100		208	−169	−98	−107		−103	−368
Decade departure							−82	556		292	76
Total excess or deficiency since first of year							−859	2,444		−641	461

* Partly estimated from sunshine record.

† Estimated from sunshine record.

TABLE 4.—*Daily normals and departures of solar and sky radiation*—Continued.

Month and day.	Daily normals.	Daily departures.					Total excess or deficiency since first of month.				
		Washington, D. C.		Mount Weather, Va.			Washington, D. C.		Mount Weather, Va.		
		1910	1911	1912	1913	1914	1910	1911	1912	1913	1914
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
May 1	494	71	−20	....	136	*92	71	−20	....	136	92
2	499	−119	151	....	128	217	−48	131	....	264	309
3	504	−72	79	....	111	*54	−120	210	....	375	363
4	509	5	131	....	61	−29	−115	341	....	436	334
5	514	192	176	....	59	−345	77	517	....	495	−11
6	518	231	194	....	−82	*−36	308	711	....	413	−47
7	520	67	82	....	−181	48	375	793	....	232	1
8	522	−224	−285	....	167	−272	151	508	....	399	−271
9	524	−122	29	....	27	*57	29	537	....	426	−214
10	526	131	132	....	200	−112	160	669	....	626	−326
11	527	−387	148	....	202	35	−227	817	....	828	−291
12	529	−331	54	....	170	99	−558	871	....	998	−192
13	530	85	68	....	−24	−352	−473	939	....	974	−544
14	531	−7	129	....	−333	94	−480	1,008	....	641	−450
15	532	91	96	....	−145	68	−389	1,164	....	496	−382
16	532	89	34	....	−236	166	−300	1,198	....	260	−216
17	532	220	*20	−162	−449	94	−80	1,218	−162	−189	−122
18	532	55	*36	120	*−92	173	−25	1,254	−42	−281	51
19	532	208	71	97	150	151	183	1,375	55	−131	202
20	532	−182	129	123	−38	106	1	1,454	178	−169	308
Decade departure	....	....	....	....	....	....	−159	785	....	−795	634
21	532	−118	67	105	−50	88	−117	1,521	283	−219	396
22	532	13	137	107	−223	33	−104	1,658	390	−442	429
23	532	*83	125	−77	−457	60	−187	1,783	313	−899	489
24	532	*56	−117	77	−211	78	−131	1,666	390	−1,110	567
25	532	214	181	−88	122	28	−345	1,847	302	−988	595
26	531	*−75	*62	192	52	77	−420	1,909	494	−936	672
27	531	75	157	131	−429	−23	−345	2,066	625	−1,365	649
28	531	195	209	−35	−339	−175	−150	2,275	590	−1,704	474
29	530	111	160	−218	1	−28	−39	2,435	372	−1,703	446
30	530	−152	154	44	−178	−60	−191	2,589	416	−1,881	386
31	530	−39	−60	176	229	196	−230	2,529	592	−1,652	582
Decade departure	....	....	....	....	....	....	−231	1,075	414	−1,483	274
Total excess or deficiency since first of year	....	....	....	....	....	....	−1,089	4,973	....	−2,273	1,043
June 1	530	−172	244	159	85	−142	−172	244	159	85	−142
2	529	113	*186	*61	203	187	−59	430	220	288	45
3	529	−417	−50	100	38	138	−476	380	320	326	183
4	529	223	45	−61	−116	−249	−253	425	259	210	−66
5	528	−470	−83	79	172	159	−723	342	338	382	93
6	528	47	−416	−101	104	130	−676	−74	237	486	223
7	527	88	−302	24	−177	112	−588	−376	261	309	335
8	527	209	*−304	221	11	−17	−379	−680	482	320	318
9	526	−344	188	148	260	−114	−723	−492	630	580	204
10	525	−394	142	190	249	28	−1,117	−350	820	829	232
11	525	−245	67	145	103	94	−1,362	−283	965	932	326
12	524	−340	20	132	241	67	−1,702	−263	1,097	1,173	393
13	524	−314	−130	4	168	187	−2,016	−393	1,101	1,341	580
14	523	−141	−37	−209	122	−430	−2,157	−430	802	1,463	150
15	523	−247	54	−432	101	−41	−2,404	−376	370	1,564	109
16	522	*−100	24	−218	96	234	−2,504	−352	152	1,660	343
17	522	8	−119	*−32	22	170	−2,496	−471	120	1,682	513
18	522	−147	−334	−146	182	88	−2,643	−805	−26	1,864	601
19	522	28	67	−330	*118	−94	−2,615	−738	−356	1,982	507
20	522	58	177	94	*4	261	−2,557	−561	−262	1,986	768
Decade departure	....	....	....	....	....	....	−1,440	−211	−1,082	1,157	536
21	523	167	243	91	*−65	69	−2,390	−318	−171	1,921	837
22	523	188	195	24	−313	−307	−2,202	−123	−147	1,608	530
23	523	*131	11	7	−452	−86	−2,071	−112	−140	1,156	444
24	523	*75	39	68	−157	106	−1,996	−73	−72	999	550
25	523	77	−166	*−218	−201	−1	−1,919	−239	−290	798	549
26	524	172	−29	−39	−285	−16	−1,747	−268	−329	513	533
27	524	−36	32	−282	8	−139	−1,783	−236	−611	521	394
28	524	−73	148	−236	−32	−68	−1,856	−88	−847	−489	326
29	524	109	225	109	11	71	−1,747	137	−738	500	397
30	524	117	236	−402	92	235	−1,630	373	−1,140	592	632
Decade departure	....	....	....	....	....	....	927	934	−878	−1,394	−136
Total excess or deficiency since first of year	....	....	....	....	....	....	−2,719	5,346	....	−1,681	1,675

* Partly estimated from sunshine record.

TABLE 4.—*Daily normals and departures of solar and sky radiation*—Continued.

Month and day.	Daily normals.	Daily departures.						Total excess or deficiency since first of month.					
		Washington, D. C.			Mount Weather, Va.			Washington, D. C.			Mount Weather, Va.		
		1909	1910	1911	1912	1913	1914	1909	1910	1911	1912	1913	1914
		Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-ca .*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
July 1	524	....	44	197	−147	54	*−350	....	44	197	−147	54	−350
2	525	....	−116	62	90	−3	*55	....	−72	259	−57	51	−295
3	525	....	−301	−1	115	148	199	....	−373	258	58	199	−96
4	525	....	−134	88	24	87	−390	....	−507	346	82	286	−486
5	525	....	64	218	78	−61	−198	....	−443	564	160	225	−684
6	525	....	185	218	158	112	−178	....	−258	782	318	337	−862
7	524	....	−205	−120	88	121	−78	....	−463	662	406	458	−940
8	524	....	48	−189	93	163	34	....	−415	473	499	621	−906
9	523	....	124	12	140	−273	47	....	−291	485	639	348	−859
10	522	....	114	90	−8	*37	46	....	−177	575	631	385	−813
11	522	....	*−21	8	54	81	134	....	−198	583	685	466	−679
12	521	....	−16	−192	140	−189	109	....	−214	391	825	277	−570
13	520	....	−20	98	11	155	−230	....	−234	489	836	432	−800
14	520	....	†74	−38	−74	−157	−241	....	−160	451	762	275	−1,041
15	519	....	29	25	−32	−194	−218	....	−131	476	730	81	−1,259
16	518	....	−71	16	−60	204	−13	....	−202	492	670	285	−1,272
17	517	....	−349	*−174	−34	−341	−25	....	−551	318	636	−56	−1,297
18	516	....	−301	29	−299	6	66	....	−852	347	337	−50	−1,231
19	514	....	−68	101	245	88	202	....	−920	448	582	38	−1,029
20	513	....	144	−48	−260	7	151	....	−776	400	322	45	−878
Decade departure	....	....	....	....	....	....	....	....	−599	−175	−309	−340	−65
21	511	....	†225	56	−149	89	103	....	−551	456	173	134	−775
22	510	....	181	204	91	89	125	....	−370	660	264	223	−650
23	508	....	22	202	134	−105	33	....	−348	862	298	118	−617
24	506	112	182	−7	−431	−40	−93	....	−166	855	−33	78	−710
25	505	161	139	217	−52	161	−202	....	−27	1,072	−85	230	−912
26	503	95	93	166	13	18	−111	....	66	1,238	−72	257	−1,023
27	501	3	−39	184	192	−8	130	....	27	1,422	120	249	−893
28	499	125	144	168	*116	6	−37	....	171	1,590	236	255	−930
29	497	60	57	114	*−111	−7	100	....	228	1,704	125	248	−830
30	495	−79	−30	−164	83	−101	25	....	198	1,540	208	147	−805
31	494	−49	192	82	−88	−57	165	....	390	1,622	120	90	−640
Decade departure	....	....	....	....	....	....	....	....	1,166	1,222	−202	45	238
Total excess or deficiency since first of year.	....	....	....	....	....	....	....	....	−2,329	6,968	....	−1,591	1,035
Aug. 1	492	....	40	191	39	−144	24	....	40	191	39	−144	24
2	490	*77	50	91	18	146	−156	77	90	282	57	2	−132
3	488	−75	117	−132	−97	47	74	2	207	150	−40	49	−58
4	486	−4	−36	−83	157	8	0	−2	171	67	117	57	−58
5	484	−50	188	−99	146	97	−116	−52	359	−32	263	154	−174
6	482	76	141	−10	−84	−229	−105	24	500	−42	179	−75	−279
7	479	84	113	*167	19	−123	*48	108	613	125	198	−198	−231
8	477	122	−373	45	−114	−95	23	230	240	170	84	−293	−208
9	474	20	99	104	−285	−178	−14	250	339	274	−201	−471	−222
10	472	76	−143	121	−71	−15	−100	326	196	395	−272	−486	−322
11	469	167	139	200	28	−190	−95	493	335	505	−244	−676	−417
12	467	−313	*10	−131	−28	−319	−243	180	345	464	−272	−995	−660
13	464	−312	−88	−16	−144	*−293	159	−132	257	448	−416	−1,288	−501
14	462	−155	73	−117	−154	−174	6	−287	330	331	−570	−1,462	−495
15	459	−317	−232	−34	35	−35	51	−604	98	297	−535	−1,497	−444
16	456	−193	−125	185	20	88	67	−797	−27	482	−515	−1,409	−377
17	454	9	−290	−61	−60	−18	80	−788	−317	421	−575	−1,427	−297
18	451	−138	−78	−7	12	−30	132	−926	−395	414	−563	−1,457	−165
19	449	89	−135	230	*−59	−111	66	−837	−530	644	−622	−1,568	−98
20	446	82	125	208	−60	160	26	−755	−405	852	−682	−1,408	−73
Decade departure	....	....	....	....	....	....	....	−1,081	−601	457	−410	− 922	249
21	444	181	−132	194	−17	137	−115	−574	−537	1,046	−699	−1,271	−188
22	441	*200	−17	200	55	−292	97	−374	−554	1,246	−644	−1,563	−91
23	439	178	105	101	5	75	88	−196	−449	1,347	−639	−1,488	−3
24	436	124	55	83	114	28	−61	−72	−394	1,430	−525	−1,460	−64
25	433	116	13	−41	15	174	−359	44	−381	1,389	−510	−1,286	−423
26	431	−27	−295	−62	14	64	−289	17	−676	1,327	−496	−1,222	−712
27	428	*178	41	56	10	19	−282	195	−635	1,383	−486	−1,203	−994
28	426	31	−85	122	26	79	−317	226	−720	1,505	−460	−1,124	−1,311
29	423	*−143	−315	−42	−108	−236	21	83	−1,035	1,463	−568	−1,360	−1,290
30	421	189	−69	−343	109	84	149	272	−1,104	1,120	−459	−1,276	−1,141
31	418	59	−140	−362	−77	82	98	331	−1,244	758	−536	−1,194	−1,043
Decade departure	....	....	....	....	....	....	....	1,086	−839	−94	146	214	−970
Total excess or deficiency since first of year.	....	....	....	....	....	....	....	331	−3,573	7,726	....	−2,785	−8

* Partly estimated from sunshine record.

† Estimated from sunshine record.

TABLE 4.—*Daily normals and departures of solar and sky radiation*—Continued.

Month and day.	Daily normals.	Daily departures. Washington, D. C. 1909	Washington, D. C. 1910	Washington, D. C. 1911	Mount Weather, Va. 1912	Mount Weather, Va. 1913	Mount Weather, Va. 1914	Total excess or deficiency since first of month. Washington, D. C. 1909	Washington, D. C. 1910	Washington, D. C. 1911	Mount Weather, Va. 1912	Mount Weather, Va. 1913	Mount Weather, Va. 1914
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Sept. 1	416	132	−302	169	38	68	88	132	−302	169	38	68	88
2	413	189	−283	−214	−11	54	139	321	−585	383	27	122	227
3	411	−79	−224	37	−175	−143	−119	242	−809	420	−148	−21	108
4	408	−158	116	169	−158	4	75	84	−693	589	−306	−17	183
5	406	75	10	−16	36	48	149	159	−683	573	−270	31	332
6	403	139	133	81	68	107	80	298	−550	654	−202	138	412
7	400	133	108	83	−15	−50	143	431	−442	737	−217	88	555
8	398	* 48	130	−181	127	−199	−89	479	−312	556	−90	−111	466
9	395	−128	−40	−146	* 120	186	82	351	−352	410	30	75	548
10	392	−226	106	63	83	160	206	125	−246	473	113	235	754
11	390	92	−222	−147	45	141	−296	217	−468	326	158	376	458
12	387	*−116	73	57	26	−98	−339	101	−395	383	184	278	119
13	384	−19	22	−93	−9	68	32	82	−373	290	175	346	151
14	382	−5	−8	176	14	* 67	116	77	−381	466	189	413	267
15	379	*−16	171	−214	−79	62	112	61	−210	252	110	475	379
16	376	−242	73	−80	41	−76	122	−181	−137	172	151	399	501
17	374	−55	65	190	81	−209	−89	−236	−272	362	232	190	412
18	371	92	83	−129	−95	−166	90	−144	11	233	137	24	502
19	368	42	−204	5	−238	−131	16	−102	−193	238	−101	−107	518
20	366	−119	6	69	* 120	−294	120	−221	−187	307	19	−401	638
Decade departure								−346	59	−166	−94	−636	−116
21	363	−29	−30	−124	101	−290	* 36	−250	−217	183	120	−691	674
22	360	−50	114	−15	*−245	72	91	−300	−103	168	−125	−619	765
23	358	6	−160	−33	−321	146	−7	−294	−263	135	−446	−473	758
24	355	*−128	−107	−59	−305	76	−170	−422	−370	76	−751	−397	588
25	352	* 155	47	67	−248	45	−105	−267	−323	143	−999	−352	483
26	350	101	122	73	−263	46	174	−166	−201	216	−1,262	−306	657
27	347	*−67	101	−71	−15	84	140	−233	−100	145	−1,277	−222	797
28	344	148	67	−32	119	120	191	−85	−33	113	−1,158	−102	988
29	342	117	113	−80	−137	−101	139	32	80	33	−1,295	−203	1,127
30	339	123	−41	197	141	−87	101	155	39	230	−1,154	−290	1,228
Decade departure								376	226	−77	−1,173	111	590
Total excess or deficiency since first of year								485	−3,534	7,956		−3,075	1,220

Month and day.	Daily normals.	Daily departures. Washington, D. C. 1909	Washington, D. C. 1910	Washington, D. C. 1911	Mount Weather, Va. 1912	Mount Weather, Va. 1913	Total excess or deficiency since first of month. Washington, D. C. 1909	Washington, D. C. 1910	Washington, D. C. 1911	Mount Weather, Va. 1912	Mount Weather, Va. 1913	Washington. 1914
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Oct. 1	336	105	80	−204	112	−85	105	80	−204	112	−85	
2	334	26	147	−210	92	−89	131	227	−414	204	−174	
3	331	† 213	76	−132	103	−100	−82	303	−546	307	−274	
4	328	10	45	48	73	135	−72	348	−498	380	−139	
5	326	11	37	159	51	100	−61	385	−339	431	−39	
6	323	* 64	40	149	* 127	31	3	425	−190	558	−8	
7	320	86	−206	−247	* 67	−258	89	219	−437	625	−266	
8	318	68	−258	140	81	−238	157	−39	−297	706	−504	
9	315	52	107	135	73	−176	209	68	−162	779	−680	
10	312	−53	139	−38	57	−156	156	207	−200	836	−836	
11	310	−206	128	19	46	−229	−50	335	−181	882	−1,065	
12	307	60	110	−13	8	* 52	10	445	−194	890	−1,013	
13	304	98	104	187	−74	95	108	549	−7	816	−918	
14	302	−101	95	54	−181	118	7	644	47	635	−800	
15	299	33	55	−187	77	−16	40	699	−140	712	−816	
16	296	−82	58	−6	120	90	−42	757	−146	832	−726	
17	293	32	116	−186	56	−39	−10	873	−332	888	−765	
18	290	−114	107	86	18	−190	−124	982	−246	906	−955	
19	287	111	−144	−16	−80	−240	−13	838	−262	826	−1,195	
20	284	57	−100	−176	94	−166	44	738	−438	920	−1,361	
Decade departure							−112	531	−238	84	−525	
21	281	−79	−73	−155	71	−53	−35	665	−593	991	−1,414	
22	278	77	−16	−183	−237	97	42	649	−776	754	−1,317	
23	275	−64	104	99	−156	94	−22	753	−677	598	−1,223	
24	272	−201	45	132	−53	−254	−223	798	−545	545	−1,477	
25	269	121	−76	148	−97	−225	−102	722	−397	448	−1,702	
26	266	92	81	100	53	2	−10	803	−297	501	−1,700	
27	263	4	−77	72	101	64	−6	726	−225	602	−1,636	
28	260	−68	137	−112	50	−39	−74	863	−337	652	−1,675	
29	257	89	45	73	49	67	15	908	−264	701	−1,608	
30	255	3	140	51	27	7	18	1,048	−213	728	−1,601	
31	252	* 73	103	−56	24	−40	91	1,151	−269	752	−1,641	
Decade departure							47	413	169	−168	−280	
Total excess or deficiency since first of year							583	−2,383	7,687		−4,716	

* Partly estimated from sunshine record. † Estimated from sunshine record.

TABLE 4.—*Daily normals and departures of solar and sky radiation*—Continued.

Month and day.	Daily normals.	Daily departures.						Total excess or deficiency since first of month.					
		Washington, D. C.			Mount Weather, Va.		Washington.	Washington, D. C.			Mount Weather, Va.		Washington.
		1909	1910	1911	1912	1913	1914	1909	1910	1911	1912	1913	1914
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Nov. 1	249	55	†77	−9	−162	93	51	55	77	−9	−162	93	51
2	246	33	*−114	63	20	56	50	88	−†37	54	−142	149	101
3	244	36	−146	110	59	66	57	124	−*183	164	−83	215	158
4	241	52	−169	−75	49	31	41	176	−352	89	−34	246	199
5	238	43	12	26	49	100	57	219	−340	115	15	346	256
6	235	−100	101	−198	*1	100	33	119	−239	−83	16	446	289
7	232	†−2	144	98	−197	61	19	117	−95	15	−181	507	308
8	230	*−2	62	−14	58	−104	−58	115	−33	1	−123	403	250
9	227	−197	98	−156	*−89	−192	63	−82	65	−155	−212	211	313
10	224	−70	−16	44	−69	−107	70	−152	49	−111	−281	104	383
11	221	30	52	107	24	−2	1	−122	101	−4	−257	102	384
12	219	45	33	−175	29	73	45	−77	134	−179	−228	175	429
13	216	−13	−1	149	−47	−40	52	−90	133	−30	−275	135	481
14	213	−12	−18	−75	51	−149	−24	−102	115	−105	−224	−14	457
15	210	−112	−31	40	−116	−174	−191	−214	84	−65	−340	−188	266
16	208	−45	−15	145	74	−176	25	−259	69	80	−266	−364	291
17	206	−1	−24	14	−8	56	−21	−260	45	94	−274	−308	270
18	203	31	*64	77	47	*71	33	−229	109	171	−227	−237	303
19	201	−34	*33	135	33	*61	−77	−263	142	306	−194	−176	226
20	199	71	147	−1	−50	*47	26	−192	289	305	−244	−129	252
Decade departure								−40	240	416	37	−233	−131
21	197	12	†47	46	42	50	67	−180	336	351	−202	−79	319
22	194	45	*−88	139	−28	53	−62	−135	248	490	−230	−26	257
23	191	−142	*57	94	26	−17	76	−277	305	584	−204	−43	333
24	189	−161	*105	−178	44	87	70	−438	410	406	−160	44	403
25	187	37	−*59	43	52	42	−40	−401	351	449	−108	86	363
26	185	62	157	−13	7	−97	24	−339	508	436	−101	−11	387
27	184	47	91	19	14	−176	−31	−292	599	455	−87	−187	356
28	182	36	−155	−137	−44	−142	49	−256	444	318	−131	−329	405
29	181	16	−62	−87	68	−102	−14	−240	382	231	−63	−431	391
30	179	62	−55	128	57	−98	−57	−178	327	359	−6	−529	334
Decade departure								14	38	54	238	−400	82
Total excess or deficiency since first of year.								405	−2,056	8,046		−5,245	334
Dec. 1	178	22	−20	139	5	−149	−55	22	−20	139	5	−149	−55
2	176	66	94	−2	−127	−27	−31	88	74	137	−122	−176	−86
3	175	40	108	−27	29	−66	−45	128	182	110	−93	−242	−131
4	173	1	−67	79	−127	35	−46	129	115	189	−220	−207	−177
5	172	37	−153	121	−131	51	−135	166	−38	310	−351	−156	−312
6	171	*22	*−117	146	*−30	−18	−151	188	−155	456	−381	−174	−463
7	171	−144	77	*111	−51	−87	−122	44	−78	567	−432	−261	−585
8	170	37	82	75	−22	90	−100	81	4	642	−454	171	−685
9	170	75	55	−18	86	83	−134	159	59	624	−368	−88	−819
10	169	42	−25	53	42	−81	−136	198	34	677	−326	−169	−955
11	169	−10	−48	74	−128	61	−135	188	−14	751	−454	−108	−1,090
12	168	−100	30	−12	79	85	−52	88	16	739	−375	−23	−1,142
13	168	*−149	109	−75	66	87	*−108	−61	125	664	−309	64	−1,250
14	167	−3	−22	−97	56	−4	*−1	−64	103	567	−253	60	−1,251
15	167	*−23	52	−123	*57	79	93	−87	155	444	−196	139	−1,158
16	166	−54	98	−147	7	56	77	−141	253	297	−189	195	−1,081
17	166	13	92	−25	−95	12	64	−128	345	272	−284	207	−1,017
18	166	21	−58	−48	−95	37	42	−107	287	224	−379	244	−975
19	165	2	−27	91	12	57	−121	−105	260	315	−367	301	−1,096
20	165	−31	−14	33	63	45	61	−136	246	348	−304	346	−1,035
Decade departure								−334	212	−329	22	515	−80
21	165	69	54	−84	47	−2	−79	−67	300	264	−257	344	−1,114
22	165	37	86	−146	50	89	−32	−30	386	118	−207	433	−1,146
23	164	49	−78	−102	−1	−150	25	19	308	16	−208	283	−1,121
24	164	50	−93	−129	−14	21	−119	69	215	−113	−222	304	−1,240
25	164	−125	90	−75	70	−136	−100	−56	305	−188	−152	168	−1,340
26	164	90	−82	−148	51	−135	100	34	223	−336	−101	33	−1,240
27	164	−38	119	−62	−11	102	50	−4	342	−398	−112	135	−1,190
28	163	15	−23	154	75	*−38	41	11	319	−244	−37	97	−1,149
29	163	−16	−24	114	17	46	−121	−5	295	−130	−20	143	−1,270
30	163	115	−38	−31	−107	57	47	110	257	−161	−127	200	−1,223
31	164	31	111	−127	−28	−21	−58	141	368	−288	−155	179	−1,281
Decade departure								277	122	−636	149	−167	−246
Total excess or deficiency since first of year.								546	−1,688	7,758		−5,066	−947

* Partly estimated from sunshine record.

† Estimated from sunshine record.

SOLAR RADIATION INTENSITIES DURING JANUARY, FEBRUARY, AND MARCH, 1915; AND THE TOTAL SOLAR AND SKY RADIATION DURING MARCH, AT WASHINGTON, D. C.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated Washington, Apr. 28, 1915.]

In Table 1 are summarized the measurements of the intensity of direct solar radiation made by the Weather Bureau at the American University, Washington, D. C., during January, February, and March, 1915.

A comparison of the monthly means with the 5-year normals published in the Bulletin of the Mount Weather Observatory, 5:182, Table 3, shows only slight departures from the normal in January and February. For the month of March, however, the means are considerably in excess of the normal.

At noon, on February 28, with the sun at zenith distance 47.7° and the corresponding air mass 1.48, the radiation intensity measured 1.50 calories per minute, which is as high as any measurement ever obtained in Washington.

Skylight polarization, measured at solar distance 90° and in the sun's vertical, with the sun at zenith distance 60°, averaged 63 per cent in January and 65 per cent in February and March, with maxima of 70 per cent in January, 69 per cent in February, and 71 per cent in March. Comparing these latter with the average monthly maxima and departures published in the Bulletin of the Mount Weather Observatory, 3:114, Table 16, it is seen that the maxima for January and February, 1915, are very close to the highest heretofore observed in these months and that the maximum for March exceeds the previous March maximum by 4 per cent.

TABLE 1.—*Solar radiation intensities at Washington, D. C., during January, February, and March, 1915.*

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance. 48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass. 1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1915. A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Jan. 1	......	1.09	0.93	0.80	0.69	......	......	......	......	......
3	......	1.29	1.22	......	......	......	......	......	0.73	......
5	......	......	0.87	0.81	0.75	0.69	0.64	0.60	0.55	0.51
7	......	1.36	1.28	1.20	1.12	1.04	0.98	0.93	0.89	......
8	......	1.28	1.19	......	......	......	......	......	......	......
9	......	......	......	0.93	......	......	......	......	......	......
13	......	1.30	1.17	1.13	1.06	1.00	0.93	0.88	0.84	0.77
15	......	1.17	1.04	0.92	0.85	0.75	0.67	0.64	0.57	0.52
26	......	1.16	1.01	......	......	......	......	......	......	......
29	......	1.23	1.12	1.02	0.92	0.81	0.77	0.65	0.58	0.54
Means	......	1.24	1.09	0.97	0.90	0.86	0.80	0.74	0.69	0.58
P. M.										
Jan. 5	......	......	1.11	1.02	0.93	0.86	0.82	0.79	0.76	0.70
7	......	......	1.21	1.08	0.99	0.94	0.89	0.82	0.74	0.71
8	......	......	1.21	1.10	1.01	0.94	0.88	0.82	0.77	0.72
10	......	1.07	0.98	......	......	......	......	......	......	......
13	......	......	1.18	1.13	......	......	......	......	......	......
15	......	•1.28	1.12	0.99	......	......	......	......	......	......
16	......	1.05	0.87	......	......	......	......	......	......	......
26	......	1.16	......	......	......	......	......	......	......	......
29	......	1.09	0.90	0.76	0.67	0.59	0.51	0.45	0.40	......
Means	......	1.13	1.07	1.01	0.90	0.83	0.78	0.72	0.67	0.71
A. M.										
Feb. 8	......	1.04	0.94	0.84	......	......	......	......	......	......
9	1.31	1.21	1.03	0.94	0.84	0.76	0.68	0.61	......	......
10	1.47	1.37	1.27	1.18	1.13	......	......	......	......	......
11	......	0.91	......	......	......	......	......	......	......	......
18	1.47	1.40	1.28	1.20	1.15	1.05	0.96	0.93	......	......
19	......	1.36	1.29	1.21	1.16	1.11	1.05	1.00	0.95	0.91
20	1.38	1.25	......	......	......	......	......	......	......	......
21	......	1.17	......	......	......	......	......	......	......	......
26	1.42	1.31	1.15	1.01	0.93	0.88	0.84	0.80	......	......
27	......	......	......	......	0.89	0.78	0.72	0.66	......	......
Means	1.41	1.22	1.16	1.06	1.02	0.92	0.85	0.80	(0.95)	(0.91)

TABLE 1.—*Solar radiation intensities at Washington, D. C., during January, February, and March, 1915*—Continued.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance. 48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°	80.7°
	Air mass. 1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
1915. P. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Feb. 6	......	......	......	......	0.84	0.74	......	......	......	......
9	......	1.29	1.20	1.12	1.04	0.97	0.90	0.83	0.78	0.74
10	......	1.37	1.27	1.18	1.09	1.02	0.96	0.91	0.87	0.82
11	......	1.03	0.85	0.68	......	......	......	......	......	......
18	......	1.39	1.29	1.20	1.12	1.04	0.98	0.94	0.90	0.85
19	......	1.31	1.19	1.10	1.00	0.95	0.88	0.82	......	......
20	......	1.23	......	......	......	......	......	......	......	......
25	......	......	1.01	......	......	......	......	......	......	......
26	1.42	1.30	1.19	1.10	1.02	0.92	0.79	......	......	......
27	......	......	......	......	......	0.77	0.68	......	......	......
28	1.49	1.37	1.25	1.15	1.05	0.97	0.89	0.81	0.75	......
Means	(1.46)	1.29	1.16	1.08	1.02	0.92	0.87	0.86	0.82	0.80
A. M.										
Mar. 2	......	1.13	1.00	0.88	0.77	......	......	......	......	......
3	1.39	1.33	1.24	1.12	1.01	......	0.82	......	......	......
4	1.44	1.34	1.25	1.18	1.11	1.05	1.00	0.94	0.90	......
8	1.36	......	......	......	......	......	......	......	......	......
9	1.43	1.30	1.19	1.11	1.04	0.97	0.91	0.88	0.84	0.81
10	......	1.23	1.08	0.93	0.76	0.67	0.62	0.58	0.55	0.51
12	1.43	1.30	1.20	1.14	1.07	0.99	0.92	0.86	0.82	0.78
13	1.45	1.37	1.27	1.17	1.13	1.08	1.01	0.96	0.91	0.87
19	......	......	0.80	......	......	......	......	......	......	......
21	1.35	......	......	......	......	......	......	......	......	......
22	1.15	1.05	0.91	......	......	......	......	......	......	......
25	......	......	......	0.82	0.71	0.64	0.59	0.53	0.48	0.43
29	1.27	......	......	......	......	......	......	......	......	......
30	1.34	1.25	1.16	1.01	0.91	0.84	......	......	......	......
31	......	1.09	0.99	0.89	0.82	0.76	0.70	0.64	0.57	......
Means	1.36	1.24	1.10	1.02	0.93	0.88	0.82	0.77	0.72	0.68
P. M.										
Mar. 1	1.44	1.31	1.14	......	......	......	......	......	......	......
3	1.42	1.29	1.21	1.11	1.03	0.97	0.91	0.85	0.79	0.74
4	1.45	......	......	......	......	......	......	......	......	......
9	1.40	1.27	1.16	1.03	0.88	0.79	0.71	0.58	0.49	......
12	1.43	1.29	1.20	1.11	1.03	0.95	0.89	......	......	......
13	1.41	1.31	......	......	......	......	......	......	......	......
15	1.08	......	......	......	......	......	......	......	......	......
25	1.15	......	......	......	......	......	......	......	......	......
28	......	......	......	0.90	......	......	......	......	......	......
29	1.27	1.20	1.07	0.96	0.88	......	......	......	......	......
31	1.30	1.23	1.06	0.94	0.84	0.75	0.69	0.65	0.61	0.55
Means	1.34	1.27	1.14	1.01	0.93	0.86	0.80	0.69	0.63	(0.64)

TABLE 2.—*Daily totals and departures of solar and sky radiation, at Washington, D. C., during March, 1915.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily total.	Departure from normal.	Excess or deficiency since first of month.	Possible sunshine.	Average cloudiness.
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Per cent.*	*0—10*
	415	107	107	84	5
	392	82	189	100	1
3	460	147	336	100	2
4	466	150	486	88	3
5	121	−197	289	4	10
6	133	−188	101	3	10
7	336	13	114	35	9
8	342	17	131	68	4
9	480	152	283	100	0
10	428	98	381	99	2
11	300	− 32	349	61	7
12	502	167	516	100	0
13	479	142	658	100	1
14	452	113	771	99	2
15	398	57	828	80	4
16	320	− 23	805	−63	9
17	470	125	930	98	5
18	423	76	1,006	92	7

TABLE 2.—*Daily totals and departures of solar and sky radiation, at Washington, D. C., during March, 1915*—Continued.

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily total.	Departure from normal.	Excess or deficiency since first of month.	Possible sunshine.	Average cloudiness.
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Per cent.*	*0—10*
19	206	−144	862	48	8
20	261	− 91	771	60	9
Decade departure			390		
21	486	132	903	98	2
22	371	15	918	82	6
23	285	− 73	845	52	7
24	234	−126	719	39	8
25	442	80	799	79	5
26	251	−113	686	55	6
27	497	131	817	90	5
28	522	154	971	100	1
29	552	182	1,153	100	1
30	543	171	1,324	83	5
31	564	190	1,514	100	0
Decade departure			733		
Total excess or deficiency since first of year			−241		

In Table 2, column 2 gives the daily totals of solar and sky radiation received on a horizontal surface. The measurements were made with a Callendar recording pyrheliometer as described in this REVIEW p. 100. Column 3 gives the departures from the daily normals given in this REVIEW, p. 106, Table 4.

The above data show less than the average cloudiness, more than average sunshine, and solar radiation above the average in intensity during March, 1915.

THERMO-ISOPLETHS FOR WASHINGTON, D. C.

By CLEVELAND ABBE, JR.

[Dated: Washington, D. C., May 1, 1915.]

On another page Prof. H. H. Kimball presents a diagram of isopleths of the combined solar and sky radiation received at Washington, D. C., throughout the year. It is of much interest to compare with such a fundamental element the resultant surface air temperatures at the same locality; and by using a similar graphic method the comparison of cause and effect is facilitated. It is important to bear in mind that the scale of hours is not the same in the two diagrams. Insolation is a function of the sun's altitude and is always referred to solar altitudes in the primary work. Hence apparent time is used in diagrams of radiation isopleths while 75th meridian time serves for the thermo-isopleths presented herewith. The

TABLE 1.—*Average hourly temperatures* (°F.) *by months at Washington, D. C., for the period 1890–1910.*

[Seventy-fifth meridian time.]

Month.	A. M. 1	2	3	4	5	6	7	8	9	10	11	Noon.	P. M. 1	2	3	4	5	6	7	8	9	10	11	Midnight.	Mean.
January	31.8	31.3	30.8	30.5	30.2	29.9	29.6	29.9	31.0	32.9	34.8	36.4	37.6	38.8	39.3	39.3	38.5	37.3	36.0	35.0	34.1	33.5	32.8	32.3	33.9
February	31.4	30.8	30.4	30.1	29.6	29.4	29.2	29.8	31.1	33.0	35.1	36.9	38.2	39.3	40.0	40.1	39.3	38.1	36.6	35.6	34.5	33.7	33.0	32.4	34.1
March	40.3	39.7	39.1	38.4	37.9	37.6	37.4	38.9	40.9	42.9	45.0	46.8	48.4	49.6	50.2	50.3	49.8	48.7	46.9	45.5	44.0	42.9	42.0	41.2	43.5
April	48.9	48.0	47.2	46.5	45.8	45.4	46.6	49.3	51.7	54.4	56.2	58.0	59.5	60.7	61.2	61.5	61.0	59.8	58.0	56.2	54.2	52.7	51.5	50.4	53.5
May	58.5	57.7	56.9	56.2	55.5	55.8	57.7	60.5	62.9	65.1	67.3	68.9	70.2	71.3	71.7	71.7	71.1	70.0	67.8	65.5	63.3	61.9	60.6	59.6	63.6
June	66.3	65.6	64.8	64.2	63.6	64.3	66.4	69.2	71.5	73.7	75.6	77.1	78.3	79.2	79.5	79.4	78.7	77.6	75.6	73.3	71.1	69.7	68.4	67.5	71.7
July	70.7	70.1	69.4	68.8	68.1	68.4	70.5	73.3	75.9	78.1	80.1	81.6	82.8	83.5	83.6	83.4	82.3	81.1	79.0	76.7	74.7	73.5	72.4	71.5	75.8
August	69.3	68.8	68.1	67.6	66.9	66.8	68.4	71.2	73.8	76.1	78.1	79.6	80.8	81.7	81.9	81.6	80.9	79.6	77.0	74.9	73.0	71.3	70.8	70.0	74.1
September	63.4	62.8	62.2	61.6	61.1	60.7	61.5	64.6	67.7	70.4	72.8	74.5	75.8	76.7	77.1	76.8	75.8	73.8	70.8	68.6	66.8	65.6	64.7	63.8	68.3
October	51.4	50.8	50.2	49.8	49.4	49.0	49.2	51.6	54.6	57.5	60.0	61.9	63.4	64.4	64.8	64.5	63.2	60.6	57.8	56.1	54.6	53.6	52.6	51.8	56.0
November	42.0	41.5	41.0	40.5	40.2	39.9	39.7	40.8	43.1	45.8	48.2	50.0	51.5	52.4	52.8	52.2	50.8	49.0	47.3	46.0	44.6	43.8	43.0	42.3	45.4
December	33.1	32.7	32.3	31.9	31.5	31.2	31.1	31.6	33.0	35.1	37.2	39.0	40.3	41.4	41.8	41.5	40.4	38.9	37.5	36.5	35.4	34.7	34.0	33.5	35.7

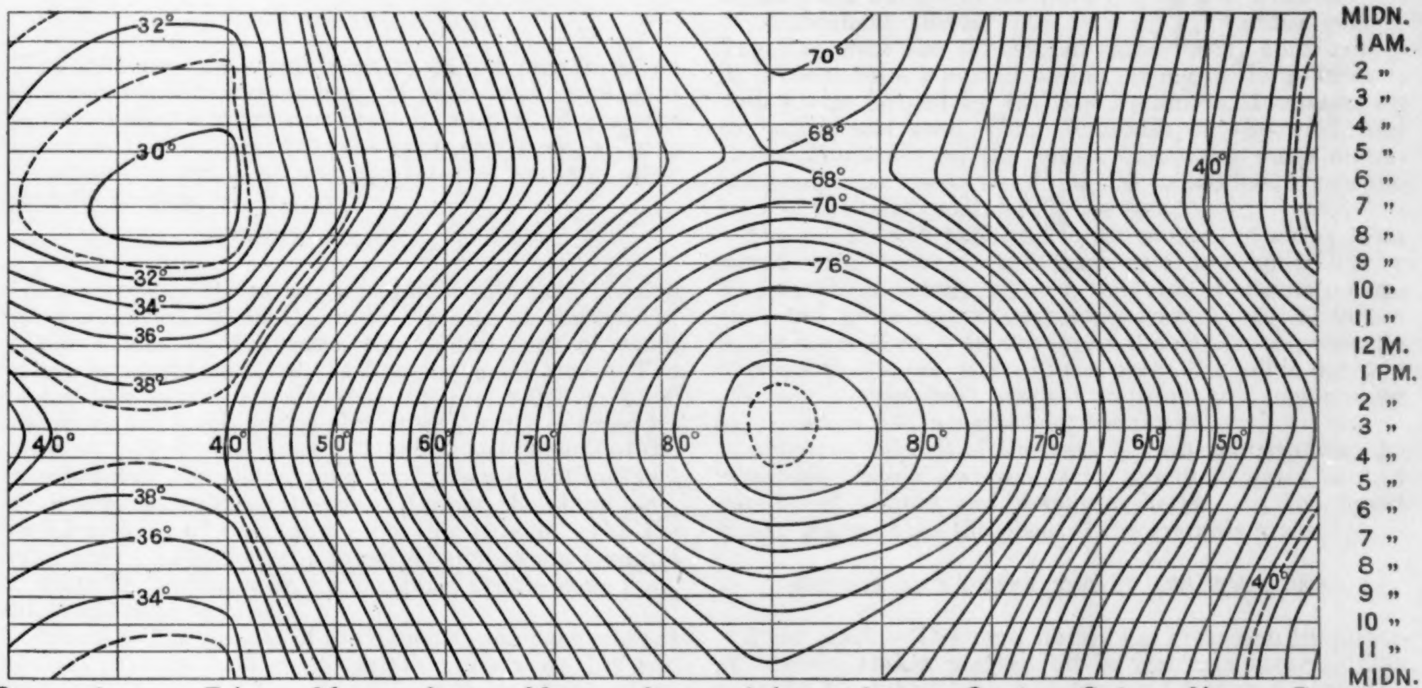

FIG. 1.—Thermo-isopleths for Washington, D. C., for the period 1890–1910. (°F.; 75th meridian time.)

difference in time may be found from column 3 of Kimball's Table 1 (p. 104).

The average hourly temperatures by months, which appear in Table 1, are the basis of the diagram of isopleths forming figure 1. They are for the interval 1890–1910, during which time the instrument (Richard thermograph) has been continuously under the same exposure in the present roof shelter at the corner of Twenty-fourth and M Streets NW. The averages were computed by Mr. Samuel A. Potter, of the Weather Bureau instrument division, who has carefully freed them from all known or suspected errors. They are here employed by his generous permission. The writer plotted them on the network used for figure 1 and drew the resulting thermo-isopleths for publication in the New International Encyclopedia. Figure 1 is here reproduced, with corrections, by permission of the managers of that publication.

Such diagrams of isopleths have been prepared, usually based upon much longer records, for many points in Europe and other continents; but not many have been presented for localities in the United States. Fassig [1] has prepared such for several elements of the climate of Baltimore; Cox and Armington [2] prepared isopleths for Chicago, and Henry A. Hazen [3] prepared them for several elements in earlier years at that same point. When an element is plotted in this manner for several differently exposed localities a comparison of the different diagrams readily reveals fundamental and sometimes unexpected contrasts. Thus, in figure 1 the varying spacing of the isopleths within the zone between noon and 5 p. m. throughout the year is characteristic for a situation similar to that of Washington. A point lying nearer the sea and to windward thereof reveals its location at once by a quite different spacing along this zone throughout the year.

Other portions of two such diagrams may be similarly compared; or advantage may be taken of the simultaneous presentation of both hours and months throughout the year to compare the diagrams as great wholes which present at a brief glance the thermal character of the whole year. Professor Kimball has already (p. 102) indicated the interesting points which develop upon comparing his radiation isopleths with these thermo-isopleths. The future may offer an opportunity to draw comparisons between such diagrams for different localities in this country.

[1] **Fassig, O. L.** The climate and weather of Baltimore, Md. Baltimore, 1907. pp. 36, 62, 74, 80, 101, etc.

[2] **Cox & Armington.** The weather and climate of Chicago, Ill. Chicago, 1914. pp. 135, 205, 207, 214, 283, etc.

[3] **Hazen, Henry A.** The climate of Chicago, Ill. Washington, 1893. (Weather Bureau bull. 10), pp. 52, 53, 54, 55, 66, etc.

SECTION II.—GENERAL METEOROLOGY.

THE INFLUENCE OF A WESTERN YELLOW PINE FOREST ON THE ACCUMULATION AND MELTING OF SNOW.

By ALEXANDER J. JAENICKE and MAX H. FOERSTER.

[Dated: U. S. Forest Service, Washington, Mar. 27, 1915.]

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PURPOSE OF THE STUDY.

The influence of a virgin western yellow pine forest on the accumulation and melting of snow was studied at the Fort Valley Experiment Station, Arizona, during the winters of 1910–11 and 1912–13 upon two areas, alike in all respects, except that one was forested and the other naturally treeless.

THE REGION.

Topography.—The areas studied lie within the Coconino National Forest on the Colorado Plateau, at the base of the San Francisco Mountains, the highest peak of which rises to an elevation of 12,794 feet above sea level. The plateau has an average elevation of from 6,000 to 8,000 feet above sea level, and is almost uniformly covered by a western yellow pine forest. The forested portion of the plateau below the yellow pine type, from 6,500 to 5,000 feet, is covered by three species of juniper, the piñon pine, several species of oak, and other hardwoods. On the slopes above 8,500 feet the principal species are Douglas fir, white fir, corkbark fir, limber pine, bristle cone pine, and Engelmann spruce.

Climate.—The climate of the region shows very marked seasonal changes, and great variations between day and night temperatures. Forests are found only at elevations above 5,000 feet. The lowlands between the mountain ranges support nothing but desert vegetation.

The average annual precipitation in the western yellow pine forest on the Colorado Plateau amounts to approximately 24 inches. Instead of being equally distributed throughout the year, it occurs in two well-defined periods, during July and August in the form of thunder showers, and from November to April in the form of snow. The period intervening between the winter snows and the summer rains, from about April 15 to July 15, is marked by desiccating high winds from the southwest. These three months of drought are exceedingly trying to vegetation. The importance, therefore, of snow as a source of water supply for irrigation projects, stock interests, and various allied industries is obvious.

Forests and parks.—In Arizona, western yellow pine grows naturally in open stands, the trees forming small, practically even-aged groups of from 2–20 individuals with various sized openings between. These openings, comprising usually not more than half an acre, make up approximately 65 per cent of the total area of the western yellow pine forest in this region.

Occasionally these openings are very large, covering several square miles, and have agricultural value. The origin of these "parks" or treeless areas, which are typical of the whole plateau, is still an undecided question.

Fort Valley Park.—Fort Valley Park, from which the experiment station takes its name, covers about 3.4 square miles and lies 9 miles northwest of the town of Flagstaff in the Coconino National Forest. The park is practically level and has an average elevation of about 7,250 feet above sea level. The general drainage is toward the southeast. The timberland surrounding the park, except in one or two places, rises on a very gentle slope. The outline of the park is irregular, with tongues of timberland jutting out into it at various places. Together with the timberland immediately surrounding it, it constitutes a partial basin opening to the southeast, with a rim formed by the San Francisco Mountains on the north and east, Wing Mountain on the west, and Crater Mountain on the south. Between these mountains ridges or mesas rise from 100 to 200 feet above the level of the park, completing the rim.

The soil in both park and forest consists of a clay loam mixed with volcanic rock fragments and underlain by cinders which usually occur in the form of alternate compact and loose layers, beginning from 16 to 30 inches below the surface. In the forest the surface is generally covered with rocks, while in the parks the soil is fine and alluvial, having been washed in from the surrounding higher areas now occupied by the forest.

About two-thirds of the park is under cultivation, the remainder being covered with gramma grass and a variety of annual and perennial herbs. In the forest bunch grasses take the place of the gramma grass.

METHOD AND CHARACTER OF OBSERVATIONS.

Snow depth.—The snow depth was measured by means of vertical stakes marked off in feet and inches. One series of 10 stakes, 2 by 2 inches by 5 feet, was placed in

the park and another series in the forest. The ground cover around the stakes was disturbed as little as possible.

The stake line was adjacent to the meteorological station of the park and represented average park conditions. (See fig. 1.). The site slopes slightly to the north. In the winter of 1910–11 the stake line extended in a northwesterly direction from the meteorological station and the 10 stakes were set at intervals of from 40 to 50 feet. In the winter of 1912–13 the stake line extended due north from the same station, with 10 stakes set at intervals of one chain or 66 feet.

A line of 10 stakes was set up in the adjacent forest, as shown, immediately south of the forest meteorological station. In order to make the forest stake line comparable to the park line, it was necessary to locate the stakes in the forest on a southerly slope of from 2 to 5 degrees, thus tending to make the records of melting of the snow in the forest higher than for the forest as a whole. In both winters the stakes were set at irregular intervals in order to represent conditions in the openings and under the groups of trees. Five of the stakes were located in various positions under the crowns of trees, and the other five in various positions in the openings. Thin 3-foot strips divided into inches and tenths of inches were attached to the stakes of both lines for the sake of more accurate measurement. In order that there might be no error in depth readings on account of the formation of small hollows around the stakes by radiation, measurements were made by laying a long thin stick on top of the snow and its line of intersection with the stake taken as the reading.

Measurements were taken immediately before and after each snowfall, whenever possible, and the readings on the park and forest stakes averaged separately. Whenever it was not practicable to take measurements immediately before and after a storm, it was always possible to take them before any appreciable settling of the new snow had occurred, and it was invariably possible to distinguish between the old and new layer of snow, and thus determine the depth of each. Care was taken to keep the snow cover around the stakes unbroken.

Measurement of melting.—The snow stakes were also used to determine the rate of melting. In the winter of 1910–11, measurement of melting was taken almost daily at the meteorological stations in conjunction with the meteorological observations. In 1912–13, daily measurements of melting, with meteorological readings, were always possible.

In the winter of 1910–11 a series of photographs (see figs. 6–9) was taken every week along both stake lines to illustrate the difference in the character of melting in the forest and park.

Water equivalents.—For determining the water equivalent of snow, a section of average depth was cut out with the overflow can of the standard raingage, and melted in a known quantity of hot water. This method is very simple, and was found to be the most accurate.

In the winter of 1910–11, water equivalents were determined only in connection with snowfall. In 1912–13, in addition to this, weekly water equivalent determinations were made of the total snow on the ground in the forest and in the park.

After the total disappearance of snow in the park, drifts of snow remained in the forest. The total water equivalent of these drifts was determined at intervals of a few days until their disappearance.

Soil moisture.—In order to determine the relative amounts of snow water absorbed by the soil in the forested and nonforested areas, and the retention of this snow water, a series of soil samples was taken in the winters of 1910–11 and 1912–13.

In the winter of 1910–11, a series of soil samples was taken weekly for four weeks beginning March 15. Another set was taken on April 29, and the last set on May 29, two and one-half months after the disappearance of the park snow. Twelve samples were taken on each date in the park, in 3 different locations and at 4 different depths. In the forest 16 samples were taken on each date, from 4 different locations, and at 4 different depths. The 4 depths at which samples were taken during this winter were as follows: 0–1 inch, 1–4 inches, 8–10 inches, 16–18 inches.

During the winter of 1912–13, the first set was taken on March 24 and the last on June 13, in the midst of the dry season. A total of five sets was taken at intervals of approximately three weeks. In the park two localities were always chosen, one a slight north slope and the other a slight south slope, and a total of 20 samples was taken at each of the following depths: 4–8 inches, 12–16 inches, 24–32 inches.

In the forest two samples were taken at each of the above depths in each of the following four situations: (1) South side of trees; (2) north side of trees; (3) directly under trees; (4) openings.

Thus the important conditions in the forest were represented. All the park and forest samples were weighed, and heated in a soil oven at 100°C. until a practically constant weight was reached. The moisture percentages are based upon the weight of the dry soil.

Soil temperature.—Since special soil thermometers were not available, soil temperatures were determined by means of common exposed thermometers suspended within a wooden casing. It was found impracticable to take readings during the winter months, because the casings became filled with water, which, on freezing, made it impossible to raise the thermometer for reading. For this reason the measurement of soil temperatures did not begin until May 1. The thermometers were placed at a depth of 2 feet. Readings were taken daily between 8 and 9 a. m.

Frost.—The capacity of a soil to absorb water from its surface is affected to a certain degree by the presence or absence of frost. During the winter of 1910–11 frost depths were determined in January, February, and March. In the forest they were determined in the openings and under the crowns. Determinations were also made during the winter of 1912–13. In the forest the following situations were selected: North side of trees, south side of trees, and openings. In the park two situations were chosen, one on a slight north slope and the other on the level.

Snow reconnoissance.—After all the snow had disappeared from the park in the spring of 1913, three 10-acre plats of *level* forest land adjacent to the park were covered by a snow reconnoissance at intervals of 4, 8, and 12 days, respectively, in order to determine the actual amount of snow retained by the forest per acre. It was thought better to distribute the reconnoissance on three different areas at three different times rather than to confine all three periodic measurements to one area. The maximum depth and the average depth of the drifts encountered was determined. In addition, the length and width of

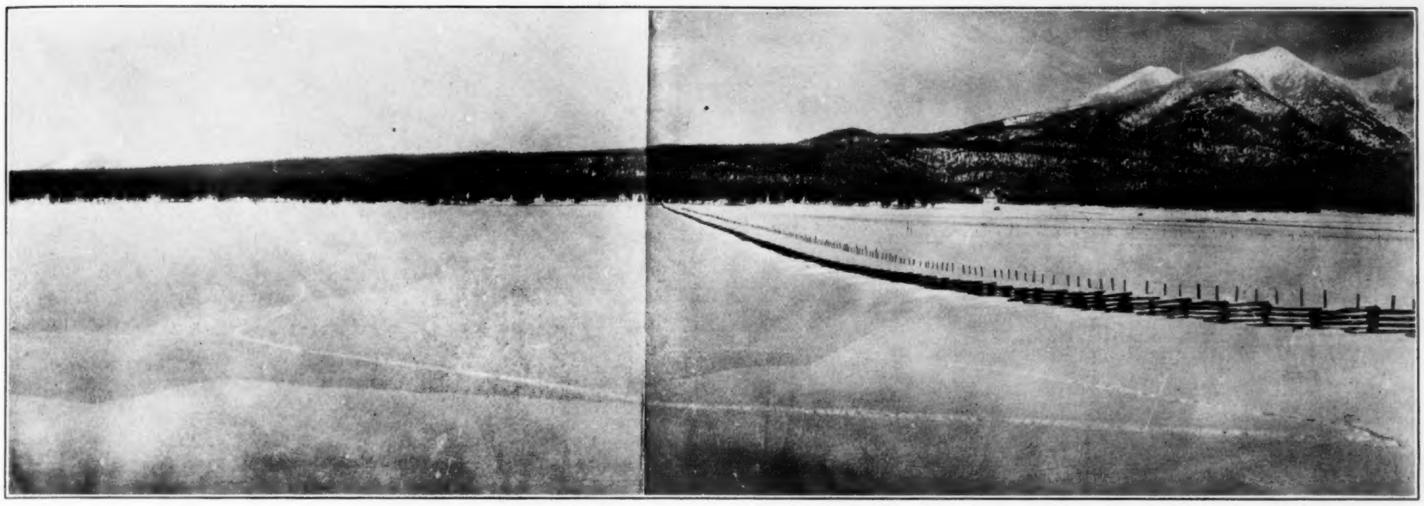

FIG. 1.—General view of Fort Valley "park" and the surrounding country, February 21, 1911. Note the snow banked on the windward side of the rail fence. Meteorological stations No. 2 (park) and No. 3 (forest) are indicated by X.

FIG. 2.—Details of meteorological station No. 3 (forest).

the drifts were measured. The water equivalent of the snow composing the drifts was ascertained at the end of each 4-day interval.

METEOROLOGICAL RECORD.

Three permanent meteorological stations are maintained at the Fort Valley Experiment Station, and since two of these are immediately adjacent to the stake lines the daily readings taken there were of great value in this study. Daily meteorological records have been kept at these three stations since January 1, 1909, by means of standard instruments furnished for this purpose by the United States Weather Bureau and installed under the supervision of its officials.

Station 1 is situated at the edge of the timber on the west side of the park, with an elevation of 7,260 feet. The apparatus consists of a maximum and minimum thermometer, a Robinson cup anemometer, a sling psychrometer, a wind vane, and an evaporation pan.

Station 2 is situated in the open park at an elevation of 7,250 feet above sea level, and has practically the same equipment as Station 1; in addition, a series of snow stakes at which snowfall and melting measurements were taken for this study. (See fig. 3.)

Station 3 is located in a typical virgin stand of western yellow pine, 1,450 feet from the edge of the park, at an elevation of 7,350 feet. The forest snow stake line begins at this station and extends in a general southerly direction to the edge of the park. (See fig. 2.)

COMPARISON OF SNOWFALL IN PARK AND FOREST.

General character of snowfall.—During normal years, according to United States Weather Bureau records at Flagstaff, Ariz., which have been maintained for 13 years, the snowfall of the winter season begins about the middle of November. The first snows, up to the middle of December, are usually light and wet and disappear very rapidly. The succeeding snowfalls are heavy and dry and keep the ground covered to a depth of 1 to 3 feet throughout the winter. Usually about the beginning of March the spring thaw sets in, causing the snow to disappear in about two weeks. Light snows occur throughout the month of March and in the early part of April. Like the first snows, these are moist, and melt soon after they reach the ground.

TABLE 1.—*Comparison of precipitation for the five winter seasons, 1908–09 to 1912–13.*

[Average of park and forest.]

Winter.	Total snowfall (Station 2).	Water equivalent.	Rain.	Total precipitation.
	Inches.	*Inches.*	*Inches.*	*Inches.*
1908–09	78.6	....	....	15.87
1909–10	71.1	8.69	1.90	10.59
1910–11	28.35	3.80	9.10	12.90
1911–12	63.2	6.55	1.62	8.17
1912–13	72.8	7.95	0.19	8.14

This brief comparison shows clearly the abnormal character of the winter of 1910–11, and the normality of the winter of 1912–13, the winter during which this study was conducted in most detail. In the winter of 1909–10, a normal one, the observations were made along the same general lines by H. D. Burrall at this station. Since the results obtained by Mr. Burrall correspond to the results during a subsequent normal and abnormal winter, the conclusions drawn in this study can be taken as applicable to this region under average conditions.

Winter precipitation, 1910–11, and 1912–13.—The winter of 1910–11 was very abnormal, and was characterized by a small total snowfall and frequent interspersing rains. The first snowfall, occurring on November 5, 1910, was light and moist, and melted the same day. Succeeding snowfalls during November were of the same character. A permanent snow cover was not established until December 20, increasing to 6.1 inches in the park and 5.7 inches in the forest until December 28. Aside from a snowfall of 1.1 inches on December 31, the snow cover gradually decreased until a heavy rain and thaw set in on January 11. Showers, now and then changing into a wet snow, occurred frequently from then on to February 4. The effect upon the snow cover was exactly that of the later spring thaws; the entire park covering disappeared within a short time, while but a few banks of snow remained in the forest openings. A fall of 3.1 inches on February 4 reestablished the snow cover which attained its maximum depth of 7.7 inches on March 4. Four days later, on March 8, the spring thaw set in and bared the park in five days. The last snowfalls in March were light and wet and, like the first snows, melted rapidly. Heavy drifting occurred but twice, during February, before an east wind blowing 50 miles an hour. Naturally more snow was displaced in the park than in the forest, since the park snow was exposed to the full unbroken force of the wind.

The winter of 1912–13 was a fairly normal winter, although preceded on October 5 by an abnormally early snow of 6 inches. This snow was very wet, accompanied by much rain and high temperatures, and entirely disappeared within a few days. On October 30 and 31 two light snows occurred, but this fall rapidly disappeared. Two light snows occurred during November, neither of which formed even a temporary snow cover. On December 8 a snowfall of 4.3 inches established a snow cover which was thereafter maintained throughout the winter, reaching a maximum depth of 23 inches in the park on February 28. Slight thaws occurred at irregular intervals during February and the first two weeks of March. The heavy spring thaw set in on March 26, and by April 3, one week later, the park snow had entirely disappeared. In the forest numerous heavy drifts of snow persisted for several weeks. Tables 2 and 3 present some of the details for each storm passing over Fort Valley Experiment Station during the winter of 1910–11 and 1912–13.

TABLE 2.—*Snowfall and wind movement for each storm during the winter of 1910–11.*

[Rainfall during winter=9.1 inches.]

Date.	Depth of snowfall.		Water equivalent of mean for park and forest.	Wind velocity.		Wind direction.
	Park.	Forest.		Park.	Forest.	
	Inches.	*Inches.*	*Inches.*	*Mis./hr.*	*Mis./hr.*	
Nov. 5	0.01	0.01	T.	4.0	2.0	e.
15	0.68	0.68	0.06	1.0	0.5	w.
16	0.05	0.05	T.	2.5	1.5	w.
19	0.05	0.05	T.	2.5	1.5	e.
Dec. 20	2.6	2.5	0.19	7.0	2.5	w.
27	5.0	4.7	0.4	2.5	1.5	w.
28	0.1	0.1	T.	2.5	1.5	e.
31	1.1	1.2	0.1	3.5	2.0	w.
Jan. 9–11	1.6	1.7	0.4	6.0	2.5	sw.
11	0.4	0.5	T.	3.5	2.0	e.
21	T.	T.	T.	4.0	2.0	sw.
Feb. 1	0.9	1.0	T.	7.0	3.0	sw.
4	3.2	3.1	0.97	2.0	1.0	sw.
13	3.0	3.0	0.4	6.0	3.0	sw.
14	0.2	0.6	T.	13.0	4.5	sw.
15	2.1	1.8	0.17	6.5	2.5	sw.
16	0.4	0.4	0.05	1.5	1.5	sw.
20	1.4	0.9	0.14	6.0	3.0	w.
26	2.9	2.1	0.40	4.0	3.5	sw.
Mar. 3	1.8	1.5	0.15	2.0	1.5	w.
4	0.9	0.8	0.2	4.5	2.5	sw.
6	0.9	0.6	0.2	....	....	w.
11	0.16	0.16	....	9.0	3.0	sw.
Total	29.45	27.45	3.83	*4.6	*2.2	

* Averages.

TABLE 3.—*Snowfall and wind movement for each storm during the winter of 1912–13.*

[Rainfall during winter=0.19 inches.]

Date.	Depth of snowfall.		Water equivalent.		Wind velocity.		Wind direction.
	Park.	Forest.	Park.	Forest.	Park.	Forest.	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Mis./hr.*	*Mis./hr.*	
Oct. 5	6.0	6.0	0.96	0.96	5.0	2.0	sw.
30	0.75	0.75	0.04	0.04	5.0	4.0	sw.
31	0.50	0.50	0.02	0.03	7.0	2.0	ne.
Nov. 11	0.4	0.4	0.11	0.11	5.0	3.0	w.
20	0.65	0.65	0.15	0.14	5.0	4.0	sw.
Dec. 1	0.4	0.4	0.07	0.07	2.5	1.5	w.
2	1.5	1.4	0.27	0.27	2.0	1.0	s.
3	T.	T.	T.	T.	2.5	2.0	w.
7	1.2	1.3	0.11	0.10	13.0	7.0	ne.
8	4.3	4.3	0.42	0.45	5.0	1.5	se.
9	T.	T.	0.02	0.02	4.5	1.0	ne.
15	0.15	0.1	0.02	0.01	7.5	4.0	sw.
21	0.1	0.1	0.02	0.02	7.0	2.5	s.
Jan. 5	0.6	0.6	0.02	0.02	3.0	2.5	w.
10	6.9	6.7	0.54	0.53	3.5	3.0	sw.
15	2.0	2.0	0.26	0.21	5.0	3.0	sw.
16	1.3	1.3	0.17	0.19	11.0	4.0	sw.
Feb. 1	1.9	1.9	0.18	0.18	2.5	2.0	s.
7	0.4	0.3	0.07	0.07	3.0	1.5	ne.
8	2.6	2.7	0.35	0.34	2.0	1.5	s.
18	0.2	0.2	0.03	0.03	7.5	4.0	sw.
19	2.6	2.6	0.23	0.21	7.5	3.0	sw.
20	0.7	0.7	0.08	0.08	4.0	2.5	sw.
21	12.0	11.7	1.29	1.22	6.5	3.0	sw.
22	2.9	2.9	0.25	0.27	7.0	3.0	sw.
23	0.7	0.7	0.08	0.08	3.0	2.0	s.
24	1.1	1.1	0.12	0.19	6.0	2.5	sw.
25	3.2	3.2	0.40	0.41	4.0	1.5	ne.
26	3.9	3.7	0.28	0.24	11.0	4.0	sw.
27	1.6	1.6	0.12	0.12	7.0	3.0	sw.
Mar. 12	3.5	3.4	0.33	0.32	8.0	3.5	sw.
13	0.5	0.5	0.06	0.06	12.0	5.5	sw.
14	0.3	0.3	0.03	0.03	6.0	2.5	n.
20	0.8	0.8	0.11	0.11	10.0	4.0	nw.
21	0.5	0.5	0.07	0.07	6.0	3.5	sw.
24	2.3	2.2	0.19	0.19	9.0	3.5	sw.
25	3.4	3.9	0.38	0.41	8.0	4.0	sw.
26	1.0	1.0	0.09	0.09	2.0	2.0	sw.
Apr. 2	0.2	0.2	0.04	0.04	10.0	4.5	sw.
Total	73.05	72.6	7.98	7.93	*6.2	*2.9	

* Averages.

Comparison of amount of snowfall in forest and park.—This has been the subject of investigation at the Fort Valley Experiment Station since the winter of 1908–9.

Table 4 shows the relative snowfall in the park and the forest for the past four winters.

TABLE 4.—*Comparison of snowfall in park and forest at Fort Valley.*

Winter of—	Forest.		Park.	
	Snow.	Water equivalent.	Snow.	Water equivalent.
	Inches.	*Inches.*	*Inches.*	*Inches.*
1909–10	69.95	8.49	72.6	8.88
1910–11	27.45	3.82	29.45	3.82
1911–12	63.9	6.74	62.4	6.36
1912–13	72.6	7.93	73.05	7.98

This record for four winters is very brief and shows no constant relation between amount of snowfall in the forest and in the park. During the latter part of the winter of 1908–09, W. R. Mattoon[1] made a yet briefer study of this subject in this locality, and concluded that the snowfall was somewhat greater in the forest because of the accelerated wind velocity over the parks, resulting in a lighter deposition of snow, a case similar to the deposition of silt in stream courses. The winter of 1911–12 also shows slight excess in the forest, but in 1909–10, 1910–11, and 1912–13 there was a slight excess in the park. So far as such studies permit, the conclusion which may be drawn is that there is no appreciable difference in the amount of snowfall in forest and park.

[1] Mattoon, W. R., Effects of Forest upon Snow waters. Forestry quarterly, 7, 246.

A great deal of snow is occasionally deposited in the tree crowns, especially during storms with very light winds and wet snow. Most of this snow is subsequently blown off into the openings within the first few days. The amount of snow thus accumulating in the crowns and subsequently blown off can not be accurately measured because of the fact that when temperatures are high enough to cause rapid melting the snow falls off in solid masses which break through the surface of the snow already on the ground, and do not increase the depth of the snow layer. A little of the snow retained in the crowns evaporates, and never reaches the ground. Temporary retention of snow in the tree crowns makes an accurate forest-park snowfall comparison practically impossible. Exclusive of this temporarily retained snow, the forest and park snowfall records for four consecutive winters show practically no difference for the two situations.

Comparison of distribution of snowfall in park and forest.—The character of deposition in the forest and the park differs greatly. In the park the snow falls in a layer practically uniform in depth except for banking on the windward and leeward sides of rail fences. In the forest most of the snow is deposited in drifts in the openings, accompanied by a very light deposit directly under the crowns of the trees. However, during a very light, dry snowfall the difference in deposition under and outside of the crowns is slight.

Tables 5 and 6, which present records of the winters 1910–11, and 1912–13, clearly show that on those occasions in the forest the snowfall directly under the crowns of the trees was very much less than on areas outside a crown cover, and that in the park the snow fell in practically an even layer.

TABLE 5.—*Total snowfall at each stake from Dec. 1, 1910, to Apr. 1, 1911.*

PARK.

Stake No.	Total snowfall.	Remarks.
	Inches.	
1	25.6	Stakes equidistant from one another in the open park.
2	29.5	
3	27.6	
4	28.9	
5	32.5	
6	32.6	
7	27.7	
8	27.1	
9	28.9	
10	28.4	

FOREST.

1	31.3	Slight protection from tree crowns.
2	16.4	Almost entirely surrounded by tree crowns.
3	29.7	Little protection from crowns.
4	18.5	Entirely protected by tree group on southwest.
5	32.5	No protection.
6	28.8	Protection from northwest which is unimportant.
7	26.8	Slight protection from group of reproduction.
8	26.9	Slight protection on west; protected on northwest.
9	23.8	Fairly well protected from all directions.
10	33.7	No crown protection.

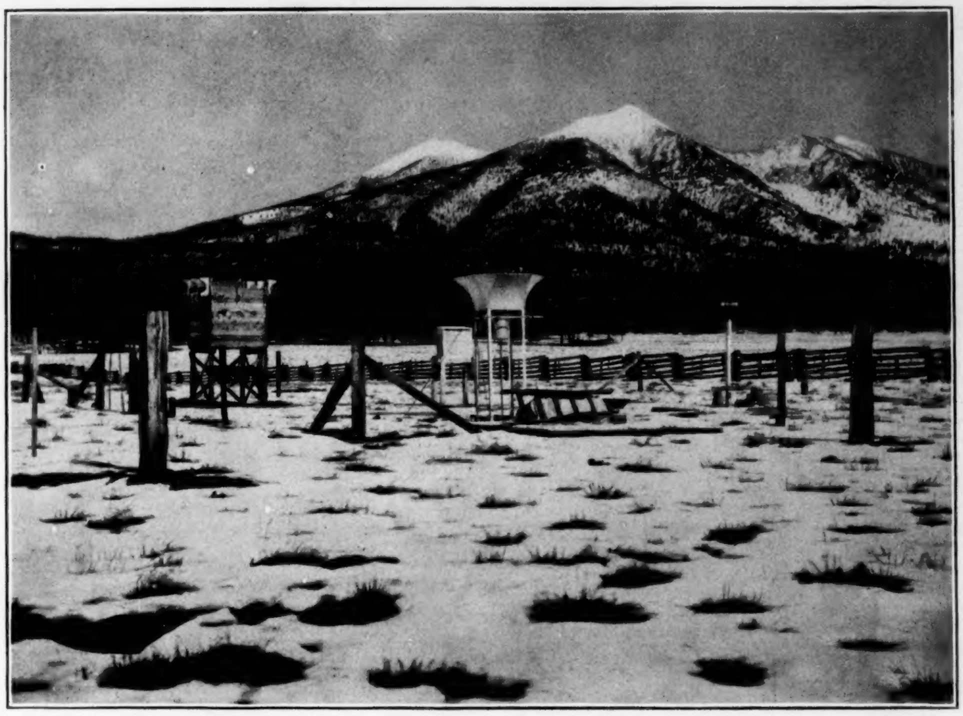

FIG. 3.—Details of meteorological station No. 2 (park). This view shows both the Bigelow "snow bin" and the Marvin shielded snow gage.

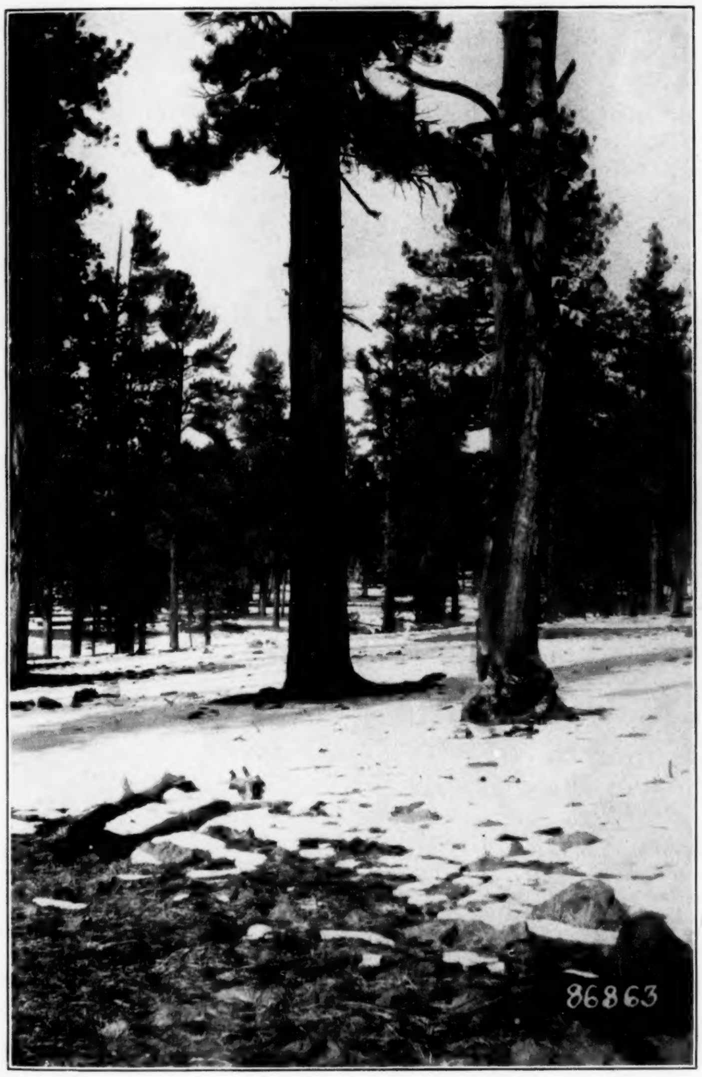

FIG. 4.—Slight influence of a high narrow crown (yellow pine) and that of a dead tree with no crown.

FIG. 5.—Greater influence of a low wide crown (blackjack).

EFFECT OF TREE CROWNS ON THE ACCUMULATION OF SNOW (FIGS. 4 AND 5).

TABLE 6.—*Total snowfall at each stake from Dec. 1, 1912, to Apr. 2, 1913.*

PARK.

Stake No.	Total snowfall.	Remarks.
	Inches.	
1	66.5	Stakes set at 66-foot intervals in the open park. Thus conditions at all the stakes are practically the same. Stakes 4, 5, 6, and 7 are on a slight north slope.
2	66.6	
3	65.8	
4	66.7	
5	62.2	
6	64.5	
7	65.6	
8	64.4	
9	61.5	
10	62.2	

FOREST.

Stake No.	Total snowfall.	Remarks.
	Inches.	
1	76.2	Practically no protection.
2	70.2	No trees in immediate vicinity. Group some distance to southwest.
3	50.6	Located in midst of group of trees.
4	61.1	Partial protection from crowns on north.
5	72.5	No protection in opening.
6	59.1	Protected by trees in all directions except northeast.
7	69.0	No trees in immediate vicinity.
8	62.2	Partial protection.
9	45.7	Located in middle of dense tree group.
10	78.1	No protection.

Detailed records of the snowfall at each stake for the individual storms during the winters 1910–11 and 1912–13, not included in this report, bring out the great diminution in snowfall directly under the tree crowns and the concentration of the greater part in the openings. In the park, on the other hand, there was only a slight difference between snowfall at the various stakes. These deep drifts in the openings of the forest persisted several weeks after all the snow in the park had disappeared. Data as to frequency and size of these drifts in the forest after total disappearance of snow in the park is given in Tables 15 and 16.

COMPARISON OF MELTING IN PARK AND FOREST.

Melting begins as soon as the snow falls, the degree depending upon several factors, chief of which is the temperature of the soil and atmosphere. Further influencing factors are slope, exposure, and radiation. Two distinct periods must be considered in the process of melting, namely, the slow melting throughout the winter and the sudden rapid melting during the spring thaws.

Winter melting.—During the winter melting is much faster in the forest than in the park, due mainly to the higher minimum and mean temperatures in the forest during these months. Table 7 gives the average of four years' records at the Experiment Station.[2]

TABLE 7.—*Comparison of temperatures in park and forest.*

[Mean=½ (max.+min.).]

1909-1912	Forest (station 3).			Park (station 2).		
	Mean max.	Mean min.	Mean.	Mean max.	Mean min.	Mean.
	°F.	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*
December	39.6	11.1	25.3	40.8	2.6	21.7
January	41.9	16.6	29.2	42.9	10.3	26.6
February	41.9	13.4	28.6	42.8	8.1	25.4
March	47.3	22.6	34.9	47.3	17.0	32.3

[2] G. A. Pearson. A Meteorological study of parks and timbered areas in the western yellow pine forests of Arizona and New Mexico. MONTHLY WEATHER REVIEW, Oct. 1913, 41: 1615–1629.

In the forest only a thin layer of snow is deposited under the tree crowns, and when this is once broken melting progresses more rapidly. Very important in the rate of melting is the radiating influence of trees, reproduction or new growth, surface rocks, and leaf litter. Even after the heaviest snowfall the ground directly under the tree crowns is almost bare within a few days. These bare areas give a further impetus to the melting of snow immediately around them. They are devoid of frost long before any situation in the park, and hence are capable of absorbing the water resulting from the melting of the snows late in the winter. This point will be brought out in detail later.

Because melting is so much more rapid in the forest before the spring thaws, the amount of snow in the forest at any given time during the winter is often less than in the park. This, together with the comparative rate of melting in the park and forest, is brought out by Tables 8 and 9.

TABLE 8.—*Fluctuations of snow cover in park and forest from Dec. 27, 1910, to Mar. 22, 1911.*

Date.	Average depth along stake line.		Water equivalent.	
	Park.	Forest.	Park.	Forest.
1910.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Dec. 27	6.0	5.6		
28	6.1	5.7		
29	3.8	4.3		
30	3.6	3.9		
31	4.7	5.1		
1911.				
Jan. 5	4.1	4.0		
6	3.8	3.7	0.7	0.6
7	3.8	3.5		
8	3.7	3.1		
9-11	4.3	4.7		
12	3.5	3.9		
13	3.0	3.5	1.16	0.91
14	2.9	3.3		
15	2.8	3.2		
16	0.6	2.2		
17	1.1	2.7		
18	0.3	2.4		
19	0.1	2.3		
20	0.0	2.1		
21	0.0	2.0		
26	0.2	2.5		
27	0.0	2.2		
28	0.0	2.0		
Feb. 1	0.9	1.6		
2	0.0	0.6		
3	0.0	0.6		
4	3.1	3.7		
8	2.9	3.3		
9	2.7	2.9		
10	2.6	2.4		
12	1.8	1.7		
13	4.5	4.7		
1911.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Feb. 14	4.8	5.3		
15	6.8	7.1		
16	7.2	7.5		
18	4.6	6.0		
19	3.6	5.5		
20	4.9	6.2		
21	4.6	5.8		
22	4.4	5.6	1.06	1.03
23	4.3	5.5		
25	4.0	6.3		
26	7.0	7.2		
28	6.1	6.5		
Mar. 1	5.3	5.8		
2	4.9	5.5	1.5	2.1
3	6.8	7.0		
4	7.7	7.8		
5	5.5	5.8		
6	6.4	6.4		
7	6.0	5.9		
8	5.7	5.4	2.51	2.33
9	3.7	3.9		
10	1.8	3.3		
11	0.2	3.4		
12	1.6	2.9		
13	0.5	2.0		
14	0.0	1.8		
15	0.0	1.7		
16	0.0	1.3		
17	0.0	0.9		
18	0.0	0.8		
20	0.0	0.6		
21	0.0	0.5		
22	0.0	0.4		
23	0.0	0.2		

TABLE 9.—*Fluctuations of snow cover in park and forest from Dec. 1, 1912, to Apr. 3, 1913.*

Date.	Average depth along stake line.	
	Park.	Forest.
1912.	*Inches.*	*Inches.*
Dec. 1	0.4	0.4
2	1.5	1.4
3	1.4	1.0
4	1.1	0.7
5	1.0	0.5
6	0.7	0.4
7	0.6	0.4
8	1.5	1.5
9	4.8	4.8
10	4.0	4.2
11	3.1	3.2
12	2.9	2.9
13	2.8	2.6
14	2.2	1.9
15	1.7	1.5
16	1.3	1.2
17	1.0	1.1
18	.9	1.0
19	.8	1.0
1912.	*Inches.*	*Inches.*
Dec. 20	0.6	1.0
21	0.5	1.0
22	0.6	1.0
23	0.5	1.0
24	0.5	1.0
25	0.5	1.0
26	0.5	1.0
27	0.3	0.8
28	0.0	0.5
29	0.0	0.4
30	0.0	0.3
31	0.0	0.2
1913.		
Jan. 1	0.0	0.2
2	0.0	0.2
3	0.0	0.2
4	0.0	0.2
	.8	0.9

TABLE 9.—*Fluctuations of snow cover in park and forest from Dec. 1, 1912, to Apr. 3, 1913*—Continued.

Date.	Average depth along stake line.		Date.	Average depth along stake line.	
	Park.	Forest.		Park.	Forest.
1913.	*Inches.*	*Inches.*		*Inches.*	*Inches.*
Jan. 6	0.8	0.9	Feb. 24	16.5	14.0
7	0.8	0.9	25	16.5	14.4
8	0.7	0.8	26	18.6	16.5
9	0.6	0.7	27	21.5	20.2
10	7.3	7.2	28	22.9	21.3
11	7.5	7.3			
12	6.2	6.0	Mar. 1	20.9	18.8
13	5.6	5.1	2	19.2	15.8
14	5.2	4.4	3	18.3	15.0
15	4.7	4.0	4	17.0	13.8
16	6.4	5.5	5	16.1	12.5
17	7.2	6.7	6	15.0	11.4
18	6.9	6.3	7	14.0	10.4
19	6.7	5.8	8	13.1	9.7
20	6.5	5.7	9	12.4	9.1
21	6.5	5.7	10	9.3	8.3
22	6.4	5.6	11	8.8	7.7
23	6.3	5.5	12	12.1	10.7
24	6.3	5.5	13	11.3	9.4
25	6.3	5.5	14	10.4	9.1
26	5.9	5.4	15	9.8	8.9
27	5.7	5.4	16	9.8	8.3
28	5.6	5.3	17	9.1	7.6
29	5.6	5.3	18	8.3	6.8
30	5.4	5.0	19	8.8	7.2
31	5.3	4.9	20	9.4	7.7
			21	8.7	6.6
Feb. 1	5.2	4.7	22	7.1	5.3
2	6.4	6.6	23	6.2	4.8
3	6.3	6.4	24	8.5	7.0
4	6.2	5.9	25	11.7	11.0
5	6.0	5.4	26	13.4	10.9
6	5.6	5.0	27	12.0	8.7
7	6.1	4.6	28	10.4	6.9
8	7.3	6.8	29	8.7	5.6
9	6.4	5.9	30	7.1	4.3
10	6.0	5.4	31	5.8	3.2
11	6.0	5.2			
12	5.9	5.2	Apr. 1	3.3	2.1
13	5.9	5.1	2	1.6	1.4
14	5.8	4.8	3	0.6	1.2
15	5.7	4.3	4	0.0	0.9
16	5.4	3.7	5	0.0	0.8
17	4.3	3.1	6	0.0	0.6
18	3.8	2.7	7	0.0	0.4
19	3.6	2.5	8	0.0	0.3
20	6.3	5.3	9	0.0	0.2
21	7.0	5.9	10	0.0	0.1
22	19.0	17.4	11	0.0	0.0
23	19.0	16.1			

Water equivalent of snow cover in forest and park during winter of 1912–13.—Weekly determinations of the water equivalent of the total snow cover in the forest and the park during the winter of 1912–13, although showing a greater total water equivalent for the park, failed to reveal any constant difference in *snow density* in the two situations for that season. In the park the snow is more fully exposed to the direct rays of the sun and the action of the wind and therefore, theoretically at least, the snow in the park should be more compact.

Table 10 shows the result of the weekly determination of water equivalents.

TABLE 10.—*Water equivalent and density of snow cover in forest and park Dec. 8, 1912, to Apr. 1, 1913.*

Date of determination.	Total snow depth.		Total water equivalent.		Snow density.	
	Park.	Forest.	Park.	Forest.	Park.	Forest.
1912.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Per cent.*	*Per cent.*
Dec. 8	1.5	1.5	0.13	0.13	8	8
15	1.7	1.5	0.34	0.27	20	18
23	0.5	1.0	0.10	0.30	20	30
1913.						
Jan. 2	0.0	0.2	0.0	0.08	....	40
9	0.6	0.7	0.11	0.11	18	16
16	6.4	5.5	0.77	0.56	18	10
24	6.3	5.5	0.80	0.58	13	11
Feb. 1	5.2	4.7	0.77	0.51	15	11
8	7.3	6.8	1.12	1.03	15	15
15	5.7	4.3	1.00	0.94	18	22
24	16.5	14.0	1.73	1.46	11	10
Mar. 1	20.9	18.8	2.11	1.95	10	10
8	13.1	9.7	1.76	1.58	14	16
15	9.8	8.9	1.95	1.69	20	19
23	6.2	4.8	2.01	1.13	32	24
Apr. 1	3.3	2.1	1.17	0.75	36	36

Spring thaws of winters 1910–11 and 1912–13.—The spring thaws begin when maximum temperatures attain about 50°F., which usually occurs shortly after the 1st of March. During the season 1910–11 the spring thaws set in about March 8. The gradual melting in the forest showed only a slight increase in its rate; but lacking the protection afforded by the forest canopy against extremes of temperature, the park snow entirely disappeared in about a week. The low minimum temperatures of the park caused the formation of an ice crust at the base of the snow layer late in the winter and in the early spring. The condition was observed particularly during the winters of 1908–9 and 1909–10, in which the ice crust attained a thickness of from 1 to 2 inches. The frequent fluctuation of the maximum temperatures, the large amount of rain, and the light snowfall during the winter of 1910–11 allowed but a very thin layer of ice, hardly more than one-fourth inch thick, to form beneath the snow. On March 13 no snow remained in the park, except a small drift along the rail fences, while banks still occupied most of the openings in the forest, both on slopes and level situations. (See figs. 8 and 9.) The last drifts within from one-fourth to one-half mile of the edge of the park disappeared on March 23, but farther back in the forest banks of snow were still visible on April 10. A series of photographs was taken every other week along the line of stakes in the park and in the forest to illustrate these differences in melting; four of them are reproduced as figures 6–9.

During the winter 1912–13 the spring thaws started about March 27, and by April 3 every trace of snow in the park had disappeared, while snow still was present directly along the forest stake line till April 10, and persisted in the form of drifts in the openings on the north sides of tree groups immediately adjacent to the stake line till April 16, as shown by Table 11.

TABLE 11.—*Measurement of snowdrifts along stake line in forest.*

Date.	1[1]	2[2]	3[3]	4[4]	5[5]	6[6]	Remarks.
1913.	Maximum depth of snow in inches.						
Mar. 29	15.6	19.5	13.0	10.2	13.7	11.5	
30	14.5	18.5	10.5	8.5	11.0	9.5	
31	13.5	17.4	8.9	7.9	9.8	8.0	
Apr. 1	10.8	15.0	8.0	7.5	8.8	5.5	
2	9.5	13.8	6.7	6.1	7.6	4.1	
3	9.0	12.4	5.6	5.1	5.7	2.3	
4	8.5	11.8	5.0	4.7	5.3	1.5	
5	6.2	10.0	3.1	2.8	2.1	0.0	No snow in park.
6	5.0	9.1	2.2	1.7	0.9	....	
7	3.8	8.2	1.0	0.4	0.0	....	
8	2.5	7.4	0.4	0.0	....	....	
9	2.0	6.8	0.0	....	....	....	
10	1.6	6.3	....	....	....	....	
11	1.2	5.7	....	....	....	....	
12	0.8	4.6	....	....	....	....	
13	0.3	3.9	....	....	....	....	
14	0.0	1.8	....	....	....	....	
15	....	1.1	....	....	....	....	
16	....	0.0	....	....	....	....	

[1] Situated 25 feet west of stake 1.
[2] Situated 30 feet west of stake 1.
[3] Situated between stakes 4 and 5.
[4] Situated between stakes 5 and 6.
[5] Situated between stakes 6 and 7.
[6] Situated immediately south of stake 7.

This persistence of drifts, in the forest after entire disappearance of snow in the park was also observed at the Fort Valley Experiment Station in the winter of 1908–9. The following is quoted from a report by W. R. Mattoon:[3]

> In the timber throughout this region there remained on April 25, a considerable quantity of snow in sheltered situations, favorable for late melting, while the last trace of snow had disappeared from the park by April 12.

These drifts occur entirely in the openings, usually on the north side of a group of trees, and are rather long and narrow—the longer dimension, as a rule, extending from east to west. The snow in the drifts is not of an even

[3] **Mattoon., W. R.** Effect of forest upon snow waters. Forestry quarterly, No. 3, 7: 246.

BIWEEKLY SERIES ALONG SNOWSTAKES.

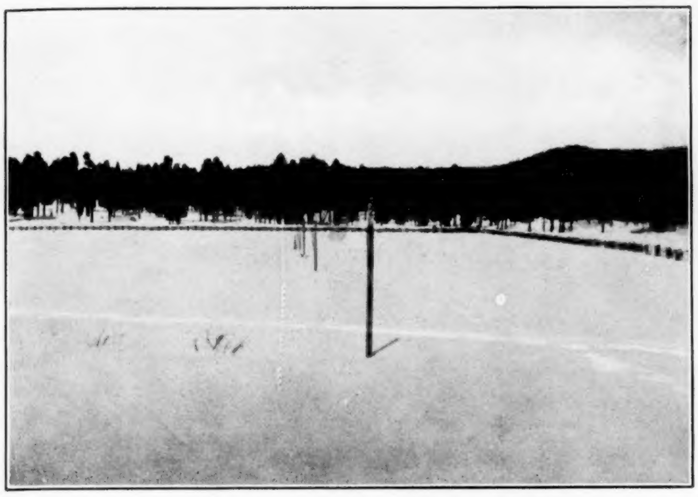

FIG. 6.—Looking northward in park, February 16, 1911.

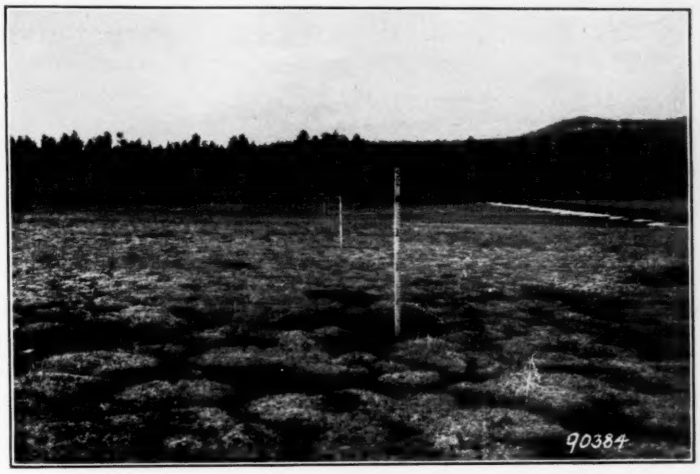

FIG. 8.—View looking northward in park, March 16, 1911.

FIG. 7.—View in forest, February 16, 1911.

FIG. 9.—View in forest, March 16 1911.

depth, nor is the snow composing it of uniform density. At the edges the snow is usually of the least depth and the greatest water equivalent, while in the middle it lies deepest and has the least water equivalent. Melting is much more rapid at the edges than in the middle of the drift, and for this reason the drift decreases not only in average snow depth, but also in length and width.

On April 3, 1913, the last snow disappeared in the park, but large drifts of snow persisted for several weeks in the openings between the tree groups in the forest. In order to determine the amount of snow thus retained by the forest, a snow reconnoissance of three sample 10-acre plots of forest was made at intervals of four days, as explained above under "Method and character of observations" (p. 115). Tables 12, 13, and 14 show clearly the advantage of a given forested area over a similar bare area in the retention of snow. The western yellow-pine forest, however, is a very open one, and therefore the retention of snow is not as marked as is the case in denser forests, such as the fir forest which Prof. Church, of the Mount Rose Observatory, at Reno, Nev., describes. The following is quoted from Prof. Church's article "Relation of forests to conservation of snow":[4]

The ideal forest from the viewpoint of conservation (of snow) is the one that can conserve the maximum amount of snow until the close of the season of melting. Such a forest should not be dense enough to prevent the snow from reaching the ground, and yet should be sufficiently dense to afford ample shelter from sun and wind. The fir forest possessing a maximum number of glades or a forest of mountain hemlock meets these requirements both theoretically and practically.

TABLE 12.—*Snow-drift reconnoissance in forest adjoining Fort Valley Park made on Apr. 8, 1913, or five days after total disappearance of snow in park.*

Greatest depth of drift.	Average depth of drift.	Dimensions.	Area of drift.	Volume of drift.
Inches.	*Inches.*	*Feet.*	*Square feet.*	*Cubic feet.*
10.0	6.0	30×150	4,500	2,250
5.0	3.5	20×25	500	146
8.5	5.2	15×40	600	260
9.0	5.0	15×60	900	375
12.9	7.3	35×150	5,250	3,194
4.0	3.5	5×10	50	15
7.3	4.0	20×70	1,400	467
7.5	4.1	15×40	600	205
9.6	6.0	30×120	3,600	1,800
8.4	5.0	35×60	2,100	875
5.5	3.0	20×65	1,300	325
5.1	2.8	15×20	300	70
9.6	7.0	25×320	8,000	4,666
6.5	4.5	10×35	350	131
9.3	6.5	10×20	200	108
8.3	6.0	15×15	225	113
Cubic feet of snow retained on 10 acres				15,000

Snow density determination April 8, 31.6 per cent, or 1 inch snow=0.316 inches water; 15,000 cubic feet snow with density of 31.6 per cent distributed on 10 acres is equivalent to 0.13 inch or 3,545 gallons of water per acre.

TABLE 13.—*Snow-drift reconnoissance in forest adjoining park Apr. 12, 1913, nine days after total disappearance of snow in park.*

Greatest depth of drift.	Average depth of drift.	Dimensions of drift.	Area of drift.	Volume of drift.
Inches.	*Inches.*	*Feet.*	*Square feet.*	*Cubic feet.*
5.5	4.0	15× 70	1,050	350
8.3	6.1	30×120	3,600	1,830
9.8	5.1	20× 60	1,200	510
10.5	7.4	15× 45	675	416
4.8	4.1	5× 5	25	9
5.7	4.0	25× 30	750	250
7.0	5.5	20×125	2,500	1,375
5.0	4.4	10× 15	150	55
5.2	4.0	30×150	4,500	1,500
9.2	4.7	15× 60	900	352
8.6	5.5	25× 45	1,125	516
5.1	3.6	15× 20	300	90
4.6	2.5	15× 75	1,125	234
5.0	2.8	10× 20	200	47
5.5	3.9	15× 25	375	122
Snow retained on 10 acres				7,656

Snow density determination Apr. 12, 37.5 per cent, or 1 inch snow=0.375 inch water; 7,656 cubic feet snow with density of 37.5 per cent distributed on 10 acres is equivalent to 0.08 inch, or 2,150 gallons of water per acre.

[4] Church, J. E., jr., Scientific American Supplement, No. 1914, 74: 155.

TABLE 14.—*Snow-drift reconnoissance in forest adjoining Fort Valley Park Apr. 16, 1913, thirteen days after total disappearance of snow in park.*

(Area C.)

Greatest depth of drift.	Average depth of drift.	Dimensions of drift.	Area of drift.	Volume of drift.
Inches.	*Inches.*	*Feet.*	*Square feet.*	*Cubic feet.*
4.5	2.9	15×40	600	145
8.3	5.0	15×65	975	406
9.5	7.2	20×25	500	300
4.6	3.2	10×20	200	53
8.7	6.0	15×30	450	225
3.6	2.1	10×25	250	44
3.1	1.7	10×20	200	28
3.4	1.5	10×15	150	19
4.0	3.5	5× 5	25	7
6.6	4.2	20×60	1,200	420
Snow retained on 10 acres				1,647

Snow density determination Apr. 16, 39.0 per cent, or 1 inch snow=0.39 inch water; 1,647 cubic feet snow with density of 39.0 per cent distributed on 10 acres is equivalent to 0.02 inch, or 481 gallons of water per acre.

Condition of the soil.—The park soil derives much less benefit from the winter's precipitation than does the forest soil, since the extremely low temperatures prevailing in the park throughout the winter cause the soil to freeze to a considerable depth. This condition of the soil and the ice layer on top of it, prevent the absorption of the great amount of snow water suddenly liberated by the spring thaws. The higher mean temperatures and the accumulation of leaf litter around the trees prevent deep freezing in the forest, as shown in the following tables. This allows the water to soak in readily.

TABLE 15.—*Depth of frozen ground in park and forest, winter 1910–11.*

Date.	Depth of frozen ground.		
	Park.	Forest.	
		Under crowns.	In openings.
1911	*Inches.*	*Inches.*	*Inches.*
Jan. 5....	9.7	5.0	6.5
Feb. 23....	6.3	2.5	3.0

Observations made on March 15, 1911, showed a surface layer of soft mud 2 inches thick in the park, with a frozen layer $1\frac{1}{2}$ inches thick below. The soil inside the forest was completely thawed out and saturated with snow water.

TABLE 16.—*Depth of frozen ground in park and forest, winter of 1912–13.*

Date.	Park.	Forest.[1]		
		North side of trees.	South side of trees.	Open.
1912.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Dec. 10..................	12.1	5.4	5.2	8.3
1913.				
Jan. 5..................	18.2	9.1	9.4	14.0
Jan. 21..................	17.0	7.5	6.8	10.5
Feb. 18..................	29.5	13.0	0.0	21.5
Mar. 24..................	23.1	3.6	0.0	8.2
Mar. 27[2]..................	20.2	0.0	0.0	7.0

[1] Depths given are the mean of two determinations.
[2] First day of the spring thaws.

The small amount of frost on the south side of the trees is attributable directly to the intense insolation, together with the presence of leaf litter, which protects the soil against freezing. The leaf litter, as shown in Table 20, is deeper on the north side than on the south side of the trees, but this added protection is more than offset by the decrease in insolation on the north side. The openings beyond the immediate influence of the

trees have the advantage of full sunlight, but lack the protection of leaf litter. Snow cover is also an important factor. If the ground is frozen before a heavy snowfall, the frost is apt to be retained longest where the snow is deepest, but if the ground is not frozen when the snow falls, the snow cover retards freezing.

TABLE 17.—*Depth of leaf litter and ground cover.*

Forest.			Park.
North side of trees.	South side of trees.	Openings.	
Inches. 1.5	*Inches.* 1.0	Light leaf litter, little grass.	Short grass cover.

Disposition of snow waters.—In the forest absorption keeps pace with melting during the winter, so that the soil is soon saturated during the first thaws. This results in a limited amount of surface run-off from the slopes. In the winters of 1910–11, and 1912–13 this run-off started earlier in the forest and continued later than in the park. However, it can in no way be compared with the enormous amount of surface run-off from the park. There the water is not able to penetrate into the frozen soil and is more or less prevented from running off freely by the still unmelted snow, so that it forms a slush with the latter and greatly hastens the final melting. The water then goes off with a rush, draining toward the Rio de Flag at the southeast corner of the park. During the spring of 1911 the Rio de Flag ran 10 to 12 feet wide and from 12 to 18 inches deep for 4 days, and continued to run as a small stream for about 10 days. This latter was the run-off from the more protected snows at the edge of the timber. Practically the same condition existed in the spring of 1913. Because there is no mutually independent forest drainage area and park drainage area of equal size in the vicinity, no exact comparative measurements of surface run-off in the park and the forest could be made. In the park it was also noticed that small bodies of standing water subject to rapid evaporation were present everywhere on level situations where it could not run off, or because of the frozen condition of the soil could not seep into the ground.

During the winter of 1908–09, W. R. Mattoon made observations on the disposal of the snow waters in the park and the forest at this station. The following is quoted from his report.[5]

The surface run-off in the two situations is interesting from the standpoint of water conservation. By April 1, bodies of water overlying the ice sheet had collected in the depressions in the park, and a good-sized stream was flowing at the outlet. No perceptible surface run-off from the forest (over the locality under consideration) occurred during March. The days of April 1, 2, and 3 were unusually warm and quiet, and resulted in the only run-off from the forest during the entire spring. The amount was insignificant compared to the total water content of the snow mass. It is well to state, incidentally, that the writer made daily trips between the two measuring stations, which afforded an opportunity for noting the conditions.

Influence of exposure.—A great contrast in the rapidity of melting is exhibited between north and south exposures. Protected from the sun's rays, there is practically no melting on north slopes during the winter months. With the approach of spring, however, the constant high maximum temperatures result in a very gradual melting. Actual measurements showed snow banks on short northerly slopes within the forest to persist 10 days after their disappearance on level situations and southerly slopes.

[5] Forestry quarterly, No. 3, 7: 246.

It was noted that a forested north slope retains its snow much longer than a nonforested one. The north slope of Crater Mountain, which rises only a few hundred feet above the south side of the park upon which it borders, offered opportunity for observations on a forested north slope and an exactly similar bare north slope, both at the same elevation. On April 2, one week after the beginning of the spring thaws of the winter of 1912–13, determinations of snow depth were made as follows: A north and south line was followed on both the bare and forested north slope, and measurements of depth taken at exactly 1 chain intervals for 21 chains, the north and south extent of the bare slope. A record was made regardless of whether snow was encountered or not. Table 18 shows a striking balance in favor of the forested north slope over the similar bare slope.

TABLE 18.—*Comparison of snow retained on a forested north slope and on a similar bare slope of Crater Mountain, Apr. 2, 1913.*

Chain No.	Depths of snow.	
	Forested slope.	Similar bare slope (same elevation).
	Inches.	*Inches.*
1	16.5	5.6
2	9.0	3.2
3	9.2	3.3
4	2.5	4.7
5	7.0	2.5
6	7.5	3.5
7	9.2	1.9
8	0.0	6.0
9	10.0	0.0
10	18.2	7.5
11	11.1	4.5
12	9.8	8.1
13	14.3	3.7
14	13.1	2.6
15	11.0	5.1
16	20.5	6.2
17	17.5	4.3
18	19.0	2.9
19	14.3	5.1
20	11.0	0.0
21	21.7	3.2
Total depth	252.4	83.9
Mean depth	12.0	3.9
Total water equivalent	3.05	1.05

The snow on the bare slope showed an average water equivalent of 0.269 inches water per inch of snow, against 0.254 inches for the forested area.

On April 10 the bare slope was entirely stripped of snow, while the forested slope contained drifts in the openings between the tree groups until May 2.

No other similar bare and forested areas with exposure other than north were available for observation. However, on April 2, 1913, the efficacy of the various forested slopes of Crater Mountain was determined by taking snow depths at chain intervals for 21 chains on the various exposures. The general results were as shown in Table 19.

TABLE 19.—*Depth of snow on various forested slopes of Crater Mountain, Apr. 2, 1913.*

Slopes.	Mean depth of snow.
	Inches.
North slope	12.00
East slope	5.21
West slope	3.65
South slope	1.23
Level situation on top of Crater Mountain	1.52

These figures indicate that the north and east slopes are most efficient in snow conservation, and that the west and south slopes are relatively less important.

MOISTURE CONTENT OF SOIL AFTER DISAPPEARANCE OF SNOW.

Factors influencing absorption and retention of soil moisture.—Determinations of the mositure content of the forest and park soils after the disappearance of the snow cover in the winters of 1910–11 and 1912–13 show a marked advantage for the former soil. Several factors bring about this difference in the absorptive and retentive capacity.

As already shown in Table 16, the frost depth in the forest is much less than in the park during the winter and spring. Obviously, therefore, the forest soil is in a better condition to absorb the water resulting from the melting of the snow. Again, in the forest there is no thick ice layer between the soil and the snow cover such as is found in the park. Soon after even the heaviest snowfall, the soil beneath the tree crowns is laid bare, which gives it an opportunity to thaw out or freeze quickly and to absorb the water resulting from the snow in the adjacent openings.

Not only is more moisture absorbed by the forest soil, but more retained, due to decreased evaporation resulting from decreased wind movement, protection afforded by leaf litter, and lower soil temperatures. Investigations of the evaporation from a free water surface in the park and the forest have been carried on for four years, and the results show that during the growing season—the only time that evaporation records can be successfully taken because of freezing of the water in winter—evaporation in the forest is only 70 per cent of that in the park.

Four years of records at the experiment station show that the wind movement in the forest is only 50 per cent of that in the park. This decreased wind movement in the forest is one of the most [?] important factors in the difference between park and forest evaporation.

With the exception of the openings, the forest soil is covered by a mulch made up of fallen needles. This covering reduces considerably the amount of evaporation from the soil, as has been conclusively shown by Prof. Ebermayer[6] in Bavaria.

A very important factor in the decreased evaporation from the forest soil is its lower temperature as compared with the park soil. The mean soil temperatures at a depth of 2 feet for May, June, and July, 1913, are given in Table 20.

TABLE 20.—*Comparison of soil temperature at a depth of 2 feet in forest and park, May 1–July 31, 1913.*

Month.	Mean temperature.	
	Park.	Forest.
	°F.	°F.
May	52.1	41.7
June	61.1	49.2
July	65.9	54.8

The soil temperatures in the forest were taken on the north side of a group of trees, representing the maximum shade. While measurements in the openings undoubtedly would show higher temperatures, the fact that the greater part of the forest soil is shaded makes it evident that the soil temperature for the forest as a whole must be less than in the park.

[6] Quoted or cited by Raphael Zon in "Forests and Water in the Light of Scientific Investigation". Appendix V, p.232, of the final report of the U. S. National Waterways Commission.

Soil-moisture determinations.—The following tables, 21, 22, 23, present the results of soil-moisture determinations made during the spring of 1911 and 1913:

TABLE 21.—*Moisture contents of forest and park soils, spring of 1911.*

[Per cent of moisture.]

Date.	Depth of sample.									
	0–1 inch.		1–4 inches.		8–10 inches.		16–18 inches.		Average.	
	Forest.	Park.	Forest.	Park.	Forest.	Park.	Forest.	Park.	Forest.	Park.
Mar. 15	38.5	29.0	31.5	26.4	26.3	23.7	27.0	28.1	30.8	26.8
23	37.0	21.7	30.6	23.5	26.0	23.7	30.1	27.9	30.9	24.2
30	35.9	16.1	29.5	21.2	24.9	23.3	31.1	27.0	30.4	21.9
Apr. 7	34.4	9.6	27.6	18.4	23.8	22.6	31.2	26.5	29.3	19.3
16	31.8	3.5	24.9	15.7	22.0	21.2	30.5	25.1	27.3	16.4
29	26.7	1.0	20.3	12.2	19.1	18.3	28.6	24.0	23.7	13.9
May 29	3.8	0.7	8.7	6.1	14.0	13.1	22.1	19.0	12.2	9.7

TABLE 22.—*Moisture contents of forest and park soils, spring of 1913.*

[Per cent of moisture.]

Date.	Depth of sample.							
	4–8 inches.		12–16 inches.		24–32 inches.		Average.	
	Forest.	Park.	Forest.	Park.	Forest.	Park.	Forest.	Park.
Apr. 14	29.2	21.7	27.6	23.9	28.9	23.4	28.6	23.0
May 3	23.1	19.4	29.9	20.4	30.9	22.6	28.0	20.8
23	19.4	15.8	19.4	17.0	22.3	18.4	20.4	17.0
June 13	12.5	7.9	21.2	14.5	25.0	21.5	19.6	14.6

The results given for the forest in Table 22 are means of soil samples from the following situations: South side of trees; north side of trees; directly under trees; openings.

TABLE 23.—*Moisture contents of soils in open and shaded situations in forest, spring of 1913.*

[Per cent of moisture.]

Date.	Depth of samples.							
	4–8 inches.		12–16 inches.		24–32 inches.		Average.	
	Open.	Shaded.	Open.	Shaded.	Open.	Shaded.	Open.	Shaded.
Apr. 14	23.7	31.0	22.8	29.1	23.9	30.6	23.5	30.2
May 3	19.8	24.2	21.4	32.8	24.2	33.0	21.8	30.0
May 23	14.5	21.0	18.3	19.7	20.8	22.8	17.9	21.2
June 13	6.5	14.4	11.3	24.5	19.0	27.0	12.3	21.9

The few soil-moisture determinations presented in summary by Tables 21–23, show the following points—

(1) The surface layers of the forest soil absorb and retain for a much longer period a greater amount of snow-water than the corresponding soil layers of the park.

(2) In the forest itself, the areas covered by leaf litter and protected by the tree crowns absorb and retain a greater quantity of soil moisture than do the bare forest openings. Hence a denser forest than one of western yellow pine would be more efficient as a retainer of soil moisture.

Tables 21, 22, and 23 are the result of soil-moisture determinations made during the spring of 1911 and the spring of 1913.

CONCLUSIONS.

The conclusions drawn from this study may be summarized as follows—

I. Snowfall:
   1. We have found no appreciable difference in the total snowfall on a forested and a nonforested area.
   2. The slight variations in snowfall which occur are due to differences in the wind velocity and temporary retention of snow on the tree crowns.
   3. The distribution of the snow on the ground differs greatly on a forested and nonforested area. The "park" snow lies in an even layer, while the forest snow is distributed in a shallow layer under the trees and in deep drifts in the openings.
   4. The amount of snow retained by the tree crowns and entirely lost by evaporation is small.
   5. During the winter the snow density in the park and forest is practically the same.

II. Melting:
   1. The rate of melting during the winter is greater in the forest than in the park, due to higher minimum and mean temperatures, lighter disposition of snow under the tree crowns, and radiation from the trees, reproduction, rocks, and logs. Because of this more rapid winter melting, the average depth of snow in the forest during the winter is less than in the park.
   2. The spring thaws cause a rapid melting of the park snow, while the rate of melting of forest snow is but slightly accelerated. The park is stripped of its snow cover within a few days, which may result in flooding, while heavy drifts of snow persist throughout the adjacent forest for two weeks or more after the total disappearance of the park snow. On account of the very open character of the western yellow pine forest it is not nearly as efficient as a snow conserver as more dense forests with smaller openings between the tree groups.

III. Disposal of the snow waters:
   1. At the time of the spring thaws, the soil in the park is frozen to a considerable depth and is covered by an ice layer which prevents thawing. Therefore, when the park snow melts during the spring thaws, the surface run-off is excessive, and absorption of soil moisture by the park soil comparatively small.
   2. In the forest the snow disappears more gradually, the soil is almost entirely thawed out, and therefore the snow waters become seepage water instead of run-off.
   3. The forest soil, aside from absorbing more moisture, retains it better than the park soil, due to protection from evaporation by decreased wind movement, shade, and leaf litter.

The foregoing conclusions make it evident that the value of forest cover in the conservation of snow waters is great, even when that forest cover is of such an open and broken character as the typical western yellow-pine forest on which observations were made in this study. For this reason, the somewhat denser forests in other regions would have a much more marked influence on snow and snow-water conservation than the yellow-pine forest of the Southwest. Again, forests can be too dense to be of much value as snow conservers, since if there are few openings the snow will have difficulty in reaching the ground and a comparatively large portion may be evaporated from the tree crowns.

In a region where water is as scarce as in the Southwest, the preservation of the forests is of the utmost importance. This applies not only to watersheds from which cities or irrigation projects derive their supply, but to all forests. The flow of springs and wells is dependent largely upon the forest which makes it possible for the rain and snow waters to percolate slowly through the soil instead of running off on the surface. The forest, by checking wind and evaporation, and tempering the extremes of heat and cold, favors the growth of other vegetation and creates conditions more hospitable to man and beast.

By proper management of our forests it is possible not only to maintain but to augment their influence. The effect of increasing the density of the stand is evident. This may be done by encouraging natural reproduction and by planting. The prevention of fires will assist in maintaining and increasing the density of the forest, and will conserve the leaf litter and other organic matter which has been shown to be of great value in absorbing and retaining water. The prevention of overgrazing will have the same effect. Heavy cutting, especially on steep slopes, must be avoided, and cutting must always be consistent with the requirements for natural reproduction. Fortunately, the conditions which favor the conservation of water on the national forests may be obtained without sacrifice. The interests of water conservation go hand in hand with those of timber production. It is not necessary to prohibit the cutting of timber on a watershed, because in scientific forestry the cuttings are so regulated that the density of the forest as a whole remains normal. Moderate grazing will not ordinarily injure a watershed, and such grazing regulations as are ordinarily necessary to conserve the water supply are also those which are necessary to maintain the productivity of the range. Cultivation, while hastening the melting of snow, places the soil in a receptive condition for water and should be favored, except on the steep slopes, where there is danger of erosion. Under the administration of the Forest Service all of these interests are being harmonized. It is the purpose to utilize every material resource on the national forests in the interest of the greatest public good. It is possible to increase the productivity of the timber, the forage, and water resources and to use them forever without danger of exhaustion.

REMARKS BY THE WEATHER BUREAU.

In seeking to disclose cause-and-effect relations between observed phenomena by the analysis and comparison of statistical data, it is often considered to be a good plan to have no preconceived theory or bias as to how the results should come out, since it is well known that statistical data can be made to support numerous propositions that have no real basis in science, logic, or nature. On the other hand, it may also lead to error if, in such studies, one disregards generally accepted physical principles broadly applicable to the problem.

The foregoing paper by two professional foresters presents a discussion of two fundamental propositions:

(1) The relative amounts of snowfall over a limited extent of forest-covered area and an open or unforested adjacent area.

(2) The relative rates of melting, in the spring, of the snow on the ground in the forest and in the open.

The data available for study are fairly complete observations for five winter seasons, during one of which the snowfall was comparatively slight. It is obvious to the meteorologist that any difference in amount of precipitation over forest and park, revealed by only five years of observations, may be most rationally explained on either the basis of wholly accidental differences in local distribution of precipitation during the short period of the observations or on residual and uneliminated errors of measurement which are well known to be very large for snowfall, rather than on the forest influence per se.

The study of the relative rate of melting of snow cover lying in the open, in the forest or elsewhere, should be approached from the point of view of the heat supply. Some snow is always vanishing from a given cover, blanket, or bed by the process of sublimation, but the process of melting is primarily a question of heat supply. The beds of snow lingering in the shadows of our houses, barns, and other shelters long after other snow exposed to unobstructed sunshine has melted, are familiar to all of us. So long as the air temperature remains near the freezing point or passes but little above it the melting of the snow in a given location is slow or rapid according to the amount of radiant heat or sunshine it receives and absorbs. This heat supply will be much greater on a surface sloping favorably southward or southwestward. The absorption will be greater in the case of snow darkened and discolored by dirt, soot, or otherwise; greater in the case of a snow surface broken up into irregular pockets as compared with snow whose surface is in a clean and glazed mirror-like condition. When the general weather conditions of a region are such that a relatively warm spell sets in, the snow cover then on the ground over the park and in the forest, for example, will be subjected to relatively high atmospheric temperatures for some days. The rates of melting must then be largely dominated by the heat supply derived from the air itself. Direct solar radiation then exerts a subordinate influence. This will be especially the case if the onset of warm weather is attended with warm rains. In these cases the influence of the forest may be of little consequence.

A forest obviously intercepts a great or a little part of the solar radiation incident upon it according to its density and character. Consequently a part only of the radiant heat reaches the ground and snow thereon is prevented from receiving the same quota of radiant heat as similar snow in the open. Observations are not needed to tell us that the melting of snow in the forests is necessarily delayed under these conditions; we have that knowledge *a priori*. The numerical data should serve, rather, to quantitatively fix the relative rates, a problem for which the present data are quite inadequate if results are expected to be representative of anything more than the particular and limited conditions under which the data were collected.

When we view the question from the point of heat supply we see at once that the forest as such is a mere incident of the conditions. The fundamental principles outlined in the foregoing as applicable broadly to the problem of the melting of snow in the forest and in the open have not received quite the attention they deserve by Messrs. Jaenicke and Foerster, and their presentation of the case permits the nontechnical reader to gain the unwarranted impression that the influence of the forest is general and fundamental rather than indirect and incidental. It is easily conceivable that the radiant heat over a park or open field could be partly cut off by the installation of artificial devices arranged to intercept solar radiation to almost any specified extent and thus artificially conserve the melting of the snow, much as the forest is found to do. This suggestion is offered simply to direct attention to the question of the heat supply as controlling the phenomena under study rather than a forest *per se*. The proposal as a commercial proposition, seems no more visionary than other efforts made by man to alter and modify nature's customary course.—[C. F. M.]

The measurements and observations carried out by Messrs. Jaenicke and Foerster in the foregoing paper are a valuable contribution to our observations on the effects of forests on various climatological factors in the Coconino National Forest. However, I think that the authors sometimes draw conclusions that are not sufficiently supported by the data they present.

In their introductory pages the authors state that the two areas they study are "alike in all respects except that one was forested and the other naturally treeless." It is very difficult to establish the fact that two areas are alike in all respects. Further, the very fact that trees grow on one area and do not naturally grow on the other area is in itself an evidence that there is some sort of difference between the two areas.

On page 116 it is stated that the method of determining the water equivalent of snow was to cut out a cylinder of snow by means of the 8-inch raingage overflow cylinder turned upside down and melt with a definite volume of water. This method is recommended by the Weather Bureau to cooperative and other observers as a simple one for determining the water value of freshly fallen snow, although it may sometimes be used for the measurement of the entire layer of snow on the ground. The method was tried out in the early days of the work of the Weather Bureau in cooperation with the Forest Service at the Wagon Wheel Gap station, but was abandoned as inconvenient, not sufficiently reliable, and not adapted to the large number of observations made in that work. The results obtained in the present case are surprisingly consistent, considering the method, and I believe that by exercising unusual care the observers have overcome the difficulties inherent in the simple apparatus they used.

On page 119 occurs the statement "During the winter melting is much faster in the forest than in the park." This comes as a surprise to many of us. Winter melting results largely from sunshine or direct insolation; spring melting is due to a combination of sunshine with higher air temperatures. While it is not the intention to dispute our authors' statement, it may properly be here pointed out that if their discovery shall be substantiated by further evidence it will overturn many theories as to what ought to happen in this connection.

The information concerning the slopes is not sufficient to permit a proper analysis of the data presented in Table 18 and the figures may be susceptible of explanation in more than one way. Slight differences in slope may have been unrecognized or the location may have been such that high winds carried the snow from the bare slope to the forested slope.

As to the conclusions on page 124, the statement under II, 2, that "heavy drifts of snow persist throughout the adjacent forest for two weeks or more after the total disappearance of the park snow" is hardly borne out by the numerical data given at the bottom of Tables 12, 13, and 14. It is there stated that the forest retained 0.13 inch water

equivalent for 5 days after total disappearance from the park, 0.08 inch was retained for 9 days, while only 0.02 inch was retained for 13 days. The conclusions concerning the relative efficiency of forests of western yellow pine are not supported by any comparisons with other covers.—[B. C. K.]

ATMOSPHERIC INFLUENCE ON EVAPORATION AND ITS DIRECT MEASUREMENT.

By Prof. BURTON EDWARD LIVINGSTON.

[Dated: Johns Hopkins University, Laboratory of Plant Physiology, Feb. 8, 1915.]

Although evaporation has long been of interest to students of meteorology and climatology this subject seems never to have assumed prime importance in either of these branches of science. The rarity of comparative evaporation records in the United States represents a condition of affairs closely paralleled in other countries and indicates that but few workers have been vitally interested in the measurement of this climatic feature. A glance through the literature of atmometry (**1**) shows that evaporation has frequently attracted the attention of individuals and that its literature includes the names of many well-known students of weather and climate. Very many methods for the direct measurement of evaporation have been described from time to time during the last two centuries, but none of these has been generally adopted by weather services for any long period. This may have been due in part to numerous apparent difficulties inherent in atmometry itself, and these difficulties have aroused hopes that evaporation may become possible of calculation from data of other climatic factors. Such hopes have led some of the most able students of atmospheric physics to attempt the experimental derivation of mathematical expressions for intensity of evaporation in terms of temperature, atmospheric humidity, and wind velocity. The problem thus suggested is fascinating to the mathematical physicist, and the inadequacy of some one evaporation formula has frequently given rise to still further attempts in the same general direction, while the direct measurement of this factor has naturally been discouraged by the hope that reliable means for its calculation may soon be forthcoming.

Within the last decade, however, there has arisen a pronounced and ever-increasing interest in direct atmometric measurements, an interest primarily due to the activities of plant physiologists, plant and animal ecologists, and students of agriculture and forestry. These workers have been led to study evaporation by the extreme importance of evaporation into the surrounding air in determining the activities of many organisms, especially plants and lower animals. It was early appreciated that the water relation seems to furnish a more satisfactory basis for many ecological interpretations (of the relations holding between organism and environment) than does any other single one of the various environmental relations. Plants show by their very structure and appearance their relations to the moisture conditions of their surroundings, while their temperature, light, and mechanical relations are not immediately nearly so patent and must be subjected to experimentation before even approximate determination may be possible. This point is well illustrated by the fact that ecological classifications of plant forms has generally been based upon the water relation. Simple inspection suffices to distinguish, with considerable precision, between xerophytes, mesophytes, and hydrophytes (representing various degrees of *xerophyly*) and these categories form the basis most commonly employed for the classification of vegetation forms. It is apparently obvious to the eye of the plant anatomist that a broad-leaved, deciduous forest must require more moisture than does a forest of needle-leaved conifers, and he sees just as clearly that prairie grasses, chaparral, and such forms as cacti and yuccas require less water than do ordinary forests, their water requirement decreasing in the order named. Natural vegetation areas and agricultural provinces have so far been charted mainly on this sort of basis. On the other hand, no very serious attempts have yet been made to classify vegetation forms with regard to their temperature or light relations (their different degrees of *thermophily* and of *photophily*, if such terms may be allowed).

When plant ecology began to emerge from its first descriptive and taxonomic phase attention was soon directed to the measurement of environmental conditions as these are related to plant activities. The most obvious, if not the most important, of these conditions, as far as the atmosphere is directly concerned, is the evaporation, and the instrumentation of plant habitats has made greater progress with this factor than with any other. Such progress has been made possible through a new development of atmometry.

Aside from this biological interest, it should here be noted that evaporation has long attracted the attention of irrigation and hydraulic engineers, from whose reservoirs evaporated water represents a considerable loss, even in humid regions. Also the direct loss of soil moisture by evaporation is frequently of great importance in agricultural operations, and this matter has not been neglected by students of this field.

The direct measurement of evaporation has recently attracted more attention from students of meteorology and climatology, who are coming to realize the practical futility of attempts to calculate the intensity of this factor from measurements of other atmospheric conditions.

The present paper deals with some considerations brought forward by the study of evaporation in its biological relations, but these considerations may not be without interest to climatologists, especially to those dealing with agricultural climatology.

Some general principles of atmometry.

The evaporating power[1] of the air here denotes its power to remove (or to allow the removal of) water vapor from any given exposed surface of liquid or solid water. This power is to be measured as the time rate of such removal (**2**).

It should be emphasized at once that the water surface from which evaporation proceeds often plays as great a rôle in the rate of water loss as do the atmospheric conditions. If different sizes, shapes, or kinds of evaporation pans, or pans containing different amounts of water, are exposed to the same complex of aerial conditions, it has been repeatedly shown that the rate of water loss per unit of surface differs for the different pans employed. If there is but slight difference between two pans, the rates of loss may appear to be the same for short-time periods, due to lack of precision in the measurements, but with pronounced differences between the pans there is no difficulty in establishing this principle.

The rate of loss in such cases is not at all directly proportional to the area of water surface exposed. *The rate*

[1] Prof. Livingston does a service in thus emphasizing the needs for intercomparable atmometers and uniform exposures so far as the latter are attainable. The Weather Bureau feels, however, that it must protest against the use of the inaccurate and misleading expression "evaporating power of the air." As Prof. Livingston himself here defines the term, the air has no power to evaporate a liquid, only to hinder that evaporation in a greater or lesser degree.—*Editor.*

of evaporation per unit of exposed water surface, under any constant complex of aerial conditions, or with this complex varying in any specified way, is a function of the uature of the atmometer. By *nature* is here meant the size, shape, material, color, etc., of the pan as well as the height of the projecting rim, the mass of water lying behind the evaporating surface, the amount of suspended sediment, etc.

Let two dissimilar pans be exposed to the same surrounding conditions, or to the same variation of conditions for a time period, and let their respective rates of water loss be determined for that period. We may suppose that pan A loses *a* times as much as pan B; thus *a* is the coefficient of correction by which the reading of B is to be multiplied in order to give the loss from A, for the given time period and for the given set of surroundings. For the second period, let the external complex of conditions be altered or let these conditions vary in some other manner from that of the first period, and the new ratio of the loss of A to that of B will probably not now be *a* as before, but the coefficient of B to the basis of A will assume some new value. This is found to hold generally in experimental tests. *Thus, the ratio of the rate of evaporation from one kind of atmometer pan to that from another kind remains constant only for some single set of surrounding conditions.*

The two principles above stated may be combined as follows: *The evaporation rate from any atmometer varies with the relation between the internal complex of conditions (the nature of the instrument) and the external complex (the surrounding conditions of the atmosphere).* Emphasis is here to be placed upon the word *relation.* It is thus possible to compare the evaporating power of the air at different stations or for different time periods only by employing instruments of like internal conditions. If the internal conditions of two instruments are alike, then their rates of water loss may be compared as proportional to the two evaporating powers of the air to which they have been respectively exposed. From this it follows that evaporation can not be measured in terms of units of depth excepting for a single specified kind, size, etc., of pan. The common practice, by which different observers of evaporation employ different sizes of pans or tanks, should, of course, be discontinued, if the records are to be generally comparable.

These general principles apply as well to other forms of atmometers as they do to the form employing a free water surface. It is logically quite impossible to "reduce" readings obtained from a Piche or from a porous-cup instrument, for example, to terms of loss from any type of pan. A coefficient for such a reduction can, of course, be obtained experimentally *for any given set of external conditions, but when the conditions* alter we must expect the coefficient to alter also. Likewise, evaporation rates from different forms or sizes of porous clay cups are differently affected by the same alterations in the surroundings, and it is quite impossible to obtain a coefficient by means of which the readings of one form may be reduced to terms of readings from another, excepting with a specific set of surroundings. Nor can porous-cup losses be reduced to terms of losses from pans or paper disks.

This whole matter is clearly stated in the single sentence: *The exposure of several evaporating surfaces must be alike if their readings are to be comparable.* The evaporating surfaces possess what I would term an internal or instrumental exposure characteristic of the nature of the instrument; only when different instruments have the same characteristic may their readings be taken as measures of the external conditions, always with reference to the particular set of internal conditions[2] presented by the kind of instrument employed. Naturally, if it is desired to measure and compare the effects of the internal conditions in controlling evaporation from two dissimilar atmometers, then it is necessary to give the two instruments exactly the same external exposures. In such a case the results reflect the influence of the internal conditions, always with reference to the particular set of external ones that obtained during the period of comparison.

Summarizing the principles above set forth "the evaporating power of the air"—that is, its power to remove water vapor, or to allow its removal from a surface of liquid or solid water—can not be directly measured except with reference to some standard atmometer having specified internal conditions or characteristics. If evaporation into the air is to be measured at different places, or for different time periods at the same place, it is quite essential that the several atmometers employed shall be as nearly alike in all particulars as is possible.

Different types of atmometers.

Choice of instruments.—If the readings of one form of atmometer can not be reduced by mathematical treatment to terms of readings that might have been had from some other form of instrument (as though the latter had operated at the same time and in the same place), then by what criteria is the investigator to decide what sort of instrument to employ in a series of comparative measurements? Obviously, from the nature of evaporation and from the medley of conditions by which it is influenced, the kind of evaporation to be studied must form the basis for this decision.

Where it is desired to approximate the rate of water loss from reservoirs and other large bodies of water, the floating pan is perhaps the most suitable instrument; it exposes a free water surface in much the same manner, both internally and externally, as does the reservoir itself. Of course it is to be remembered that different parts of such a reservoir are not usually subjected to the same rate of evaporation—the windward portion of the surface, for example, is subjected to a higher rate than is the leeward portion. This makes it frequently desirable to arrange floating pans at a number of selected places over the surface of the reservoir, just as an agriculturist takes numerous soil samples from the same field, and does not rely upon a single sample taken at some particular place.

Where the study in hand involves the measurement of evaporation as it affects plant transpiration, some form of water-impregnated paper or porous clay surface is to be chosen; such surfaces may be given an internal and external exposure fairly comparable to that of transpiring plant parts. If large plants are involved (as trees in a forest), it is clear that all parts of the plant are not subjected to the same evaporation conditions, and a number of instruments must be employed, properly placed to give the required information(**3**). To study evaporation from soils, a box or pan of moist soil seems more logical as an

[2] "Characteristic" is more popular and not specific enough. A condition is an effective characteristic, one that influences the rate of the process under consideration. The rate of a process is a function of the intensities or powers of the conditions that influence it. Conditions are frequently called factors. but are not always these, in mathematical sense; they might be terms or exponents, and frequently are. Arguments is the proper mathematical term, I should say. This is not clear enough to the general reader to be here employed.

I am insisting on the retention of the more precise word "condition" and am accepting the word "characteristic" as an appositive thereto.

Phenomena occurring at any surface are conditioned or controlled in their rate by conditions, some of which are effective on one side and some on the other side of the surface.—*Author.*

instrument than does a pan of water, though water-impregnated paper and porous clay surfaces may also be adapted to this need.

In short, the surface by means of which evaporation is to be measured should possess as nearly the same form as possible and should be given the same kind of external exposure as have the evaporating surfaces whose action is to be studied.

Aside from this general principle, however, there are various special considerations connected with the use of each form of atmometer so far devised. A few of these considerations may find place here.

The free water surface.—Free surfaces of liquid water can be readily exposed only in a horizontal plane. They are therefore not suited to studies dealing with the transpiration of ordinary plants or with evaporation from other nonhorizontal surfaces. Even if this is the kind of exposure desired, it must be borne in mind that such a water surface alters from time to time, which amounts to stating that an open pan of water is not an instrument with constant internal conditions or characteristics. In the first place, wind alters the form of the surface and its relation to the water mass behind it. Also wind frequently causes spray and splashing. In most pan atmometers the amount of water present varies considerably, addition of water, to replace that lost by evaporation, occurring only spasmodically. Water is added to such an atmometer in times of rain, and raindrops frequently cause undetermined removal of water through splashing and the formation of spray. Animals, such as birds and insects, interfere with the proper operation of open tanks; they may remove water, or they may become caught on the surface or within the tank. All of these features clearly result in internal alterations in the instrument and thus make it inadequate for serious studies. Finally, even fair accuracy of reading for short periods has never been possible with free surfaces; only small pans can be carefully weighed; the instruments must be protected from wind during weighing operation, and the variations in rate of water loss due to unknown causes become very large when periods of minutes or hours are employed.

The Piche atmometer.—The Piche instrument (**4**) employs a horizontally placed disk of water-imbibed [3] paper, supplied with water at its center, from above. Waves and splashing, considerable removal of water by animals, and serious obstruction of the surface by the bodies of the latter, are here not encountered. The entire instrument may be readily weighed, or it may be read in volume units. Small readings are, however, difficult and not very accurate. Strong wind is apt to deform the paper disk. This instrument must always operate as a unit; it is practically impossible to place the evaporating member at a distance from the graduated reservoir, an arrangement frequently requisite in botanico-physiological and ecological studies. Since all the water evaporated must pass laterally through the paper disk, from the central point of supply to the place of final vaporization, the size of the disk must be suited to the rate of evaporation to be dealt with. In a region of low evaporation intensity the disk may be large, but must be smaller in an arid region (to prevent the edges becoming dry at times).

[3] Dictionaries say "imbibed" is obsolete, in the sense of a water-imbibed solid. Newton used it so. It is perfectly clear (as clear as "drunk" in the expressions: The wine is drunk by the man and the man is wine-drunk; the two words "drunk" and "imbibed" are parallel), can lead to no ambiguity, and it can not stay obsolete if we keep using it. Impregnated is not as good, because "imbibed" suggests imbibition and the attractive force of imbibition, while "impregnated" suggests pressure from without the solid as the cause of the liquid entering. There are no other words in Roget that come as near to what we want.

"Saturated" means an entirely different thing; the paper of a Piche atmometer may be saturated as the instrument operates; but I doubt if this is the case. It is imbibed with water, whether it is 1 or 2 or a hundred per cent saturated. Saturation implies the complete disappearance of the solid's attraction for water (imbibing force) at the limit when all the water that can be imbibed has been imbibed.—*Author.*

The Piche-Cantoni atmometer.—The Cantoni (**5**) modification of the Piche instrument has the reservoir below the paper disk. Practically all the essential details of operation and interpretation of readings are the same as in the Piche instrument. Exceptions are that the more or less spasmodic water movement consequent upon having the reservoir above is here avoided; also, that the evaporating surface may be located at some distance from the reservoir and at any angle permitting a more satisfactory relation to plant foliage, etc. Strong wind is apt to deform it, as also in the Piche arrangement, in somewhat the same manner as it deforms a free water surface.

It should here be pointed out that the Cantoni modification depends upon the fact that the position of the imbibed blotting-paper disk that covers the upper end of the supply tube from the reservoir below, does not permit the passage of air as a gas, so that the difference in hydrostatic pressure between the level of the paper disk and that of the water surface in the reservoir is borne as a gas pressure by the wet paper. If the joint between paper and tube is not air-tight against this amount of pressure from without, then air enters, the water column drops in the supply tube, the water connection to the disk is broken, and the disk soon becomes air-dry. This same principle is employed with the Bellani porous plate and with the Babinet porous cup.

The Bellani porous clay plate.—Bellani's (**6**) instrument is practically comparable to a free water surface and avoids all the difficulties of such surfaces, but appears never to have attracted serious attention during the 95 years that have passed since it was described. A horizontal porous clay disk closes the top of a vessel completely filled with water, so that the lower surface of the disk is in contact with the liquid, while the upper surface is exposed to the air. Bellani's arrangement for reading should be replaced by joining the vessel of water which adjoins the plate, by means of a tube, to a lower reservoir—which may be a burette, for example. This is the earliest form of atmometer with imbibed solid evaporating surface and with the water reservoir at a lower level than the evaporating surface. The arrangement involves the same principle as that employed in the Piche-Cantoni instrument, but here the supply tube is enlarged to form the vessel above mentioned and the porous disk does not project beyond the margin of this vessel. It should be emphasized that, whereas the Cantoni instrument (and the Piche as well) depend upon lateral movement of water through the absorbent material, the Bellani plate transmits water perpendicularly to its surfaces from the lower to the upper, and evaporation here occurs from the upper surface alone.

The Bellani surface may be exposed like free water, horizontally, or it may have any other position. It requires no projecting rim and, of course, waves, spray, and splashing can not occur. At the same time, the relation of the exposed surface to the water mass below is not markedly different (especially as regards heat conditions) from the similar relation for an open pan. The evaporating surface may be placed at some distance from the graduated reservoir and very small readings may readily be made in volume units. It may be rendered nonabsorbing, and thus freed from rain-absorption by the use of the mercury valve to be described below.

The porous clay cup atmometer.—The use of porous clay cups or bougies for atmometric measurements was first suggested by Babinet (**7**), whose short account was emphasized 20 years after, in an appreciative discussion by Marié-Davy (**8**).

Forty-six years after Babinet's publication Mitscherlich (**9**) independently devised this instrument, for agricultural experimentation. The present writer (**10**) again devised it, also independently, in the summer of 1904, for use in transpiration studies. During the last decade the subject of atmometry has developed very rapidly, especially in biological connections, and most of this development has been based upon the use of the porous clay cup.

The essential part of this atmometer is a hollow cup of unglazed porcelain, closed by a stopper at its lower end and joined, by a tube through the stopper, to a reservoir below. Cup and tube are filled with water. The porous walls of the cup become imbibed with water and the latter evaporates from the exterior and is supplied from the water-mass within, the water moving outward through the porous walls in a manner quite analogous to that exhibited by the Bellani plate above described. Atmospheric pressure acts directly upon the water surface in the reservoir below, which may be a burette or bottle, or any suitable container, and the water mass within the cup is shielded from this pressure by the imbibed porcelain, which does not allow gas to enter, except in solution. Thus the porous cup remains full of water, no matter at what rate evaporation proceeds, so long as the water level in the reservoir is above the lower opening of the supply tube, and so long as the porous material allows water movement to the surface as fast as evaporation proceeds. The amount of evaporation occurring during any time period is the amount of water removed from the entire apparatus. It is usually taken as the amount removed from the reservoir, but this, of course, neglects any consideration of alterations in the specific volume of the liquid due to temperature change. Readings are most precisely made by weighing the instrument, but such refinement is not usually requisite.

To prevent the absorption of rain water through the walls of the cup, it is only necessary to install in the supply tube a mercury valve, which allows water to pass in one direction but prevents its continued movement in the other. Figure 1 shows Livingston's atmometer as recently improved by Shive (**11**).

The valve has the following construction: The glass supply tube, *B*, reaching downward from the cup, is expanded into a small bulb, *C*, below which the tube is bent upward for a few centimeters at *B′*, and then downward again to terminate below the first bend. Mercury is placed in the U thus formed. As evaporation proceeds the mercury drops in the arm *B′* of the U and rises in the other, but immediately spreads out laterally in the bulb, thus producing only a very short column. Around this mercury in the bulb the water passes from reservoir to cup. When rain falls evaporation is so far decreased that the outer surface of the cup becomes covered with an external water film, and atmospheric pressure forces this water into the cup with a pressure equal to that exerted by a water column reaching from the water level in the reservoir to the level of the point in the cup where entrance is in progress. Then mercury is forced down from the bulb and up in the other arm of the U until a sufficient mercury column is there present to balance the water column just mentioned. After this no more water can enter the cup; that falling upon it flows from the surface as though this were impervious. When the rain ceases and evaporation increases the valve reverses. It is obvious that a small amount of water does enter the reservoir with each change from conditions of evaporation to those of absorption, but this amount is very slight. Harvey (**12**) found the error in reading thus introduced by each reversal of the valve to amount to only about 0.01 cc., this magnitude depending upon the bore of the U-tube and the height of the cup above the water level in the reservoir.

The form of porous clay cup now generally employed by workers in physiology, ecology, agriculture, and forestry, is practically the same as the one described by the present writer in 1906 (fig. 1.) These cups are cylindrical, about 13 cm. long and 2.5 cm. in diameter, closed at the upper end to produce a hemisphere and strengthened at the other by a thickened rim. The wall is from 3 to 4 mm. thick, the rim having about double this thickness. They are white, with smooth, porous and absorbent exterior surface. They are closed in use by a rubber stopper bearing the tubing connection to the reservoir. The lower portion, at the open end is glazed or otherwise rendered impervious to water, leaving the upper part, 8 cm. in length, as the actual evaporating surface. For the last few years, about a thousand of these cups have gone into use each year.

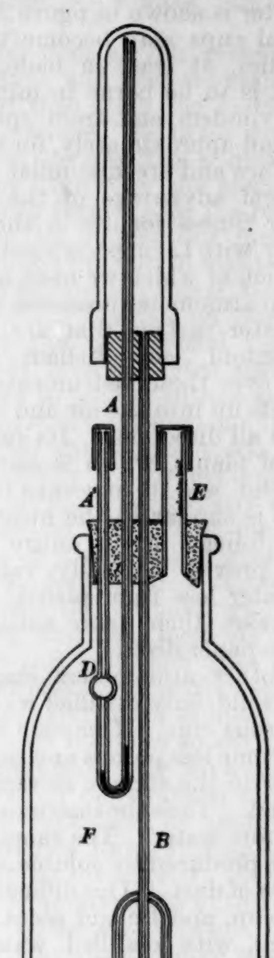

FIG. 1.—Shive's non-absorbing mounting, with cylindrical porous-cup atmometer. Above is a cylindrical porous cup with two glass tubes, *A* and *B*, entering the cup through a rubber stopper. Below is the reservoir bottle whose mouth is closed by a 4-perforate stopper. The short, graduated filling tube, *E*, is covered by a cap. The tube *ADA′* serves to fill the porous cup when suction is applied at *A′*, and the mercury valve below the bulb *D* prevents entrance of air. The second mercury valve, at *CB′*, allows water to enter the porous cup but practically prevents movement in the opposite direction.

Recently a marked improvement in the form of the cup has been achieved, first by Prof. W. L. Tower (**13**) and later by the present writer. This improvement consists in substituting a spherical surface for the cylindrical and hemispherical one of the ordinary cup. The spherical cups are 5 cm. in diameter, with a glazed, cylindrical neck below, the latter 1.5 cm. in diameter and 3 cm. long. The neck of the Tower spheres is somewhat larger and reenforced by a thickened rim. The Livingston spherical cup atmometer is shown in figure 2.

These spherical cups may become the standard [4] for atmometric studies, at least in biological connections. In this regard it is to be borne in mind, however, that readings from cylinders and from spheres can not be homologized except approximately, for they expose different forms of surface and are dissimilar in other respects. The chief practical advantage of the spherical surface lies in its greater fitness for use in the measurement of sunshine intensity, with Livingston's radio-atmometer (**14**) into a consideration of which we need not here enter.

The porous-cup atmometer possesses all the advantages over the free water surface that are possessed by the Piche, Piche-Cantoni, and Bellani instruments. Its main advantage over these instruments lies in this, that its surface projects up into the air and is exposed equally to wind action in all directions. Its surface is somewhat similar to that of plants, which is also the surface of a water-imbibed solid, and its exposure to the surrounding aerial conditions is similar to the mean exposure of the surfaces of the foliage of an entire plant. For this reason it has proved specially valuable in studies bearing upon water loss from plants. The rigidity of the cups also makes them more satisfactory than the somewhat flexible paper disks.

As with the other atmometers employing a water-imbibed, porous, solid, only distilled water should be employed in the porous cup. If impure water is used, the imbibed walls become less porous and soon become unable to transmit water to the surface as rapidly as it may be lost by evaporation. Thus the instrument itself is altered by the use of impure water. The same effect of clogging the pores may be produced by soluble salts falling on the surface in the form of dust. This difficulty can be avoided with the porous cup, and Bellani plate, by frequent and thorough washing, with distilled water and a brush. With the paper disks such washing is of course impossible and the disks must be renewed at frequent intervals.

The porous cup, the Bellani plate, and the Piche-Cantoni paper disk may all be mounted so as to permit exceedingly small readings to be made, in units of volume. With a suitable pipette as reservoir, it is easily possible to read hundredths of a cubic centimeter of loss, and this features recommends these instruments wherever low rates or short time intervals are involved.

Standardization.—It is impossible to obtain large numbers of Livingston's porous atmometer cups that are exactly alike, and the small differences met with are corrected for by the use of a coefficient of correction, obtained by standardization. A number of selected cups are preserved as standards, washed after each day's use to prevent any alteration in their porosity, etc., and one or more of these is operated upon a rotating table (**15**) along with the cups to be standardized. Thus the internal differences of the cups are measured in terms of differences in their rates of water loss under the same external conditions, and a coefficient of correction is obtained by which to multiply the reading of any cup in order to obtain the reading that would have been obtained had the place of the cup in question been occupied by a standard cup. It is well to re-standardize from time to time in order to detect any changes in the cups, but daily washing practically removes the necessity of this if the best quality of cup (known as "insoluble") is used. Nevertheless, the only way to be sure that an instrument has not altered in operation is to re-standardize it.

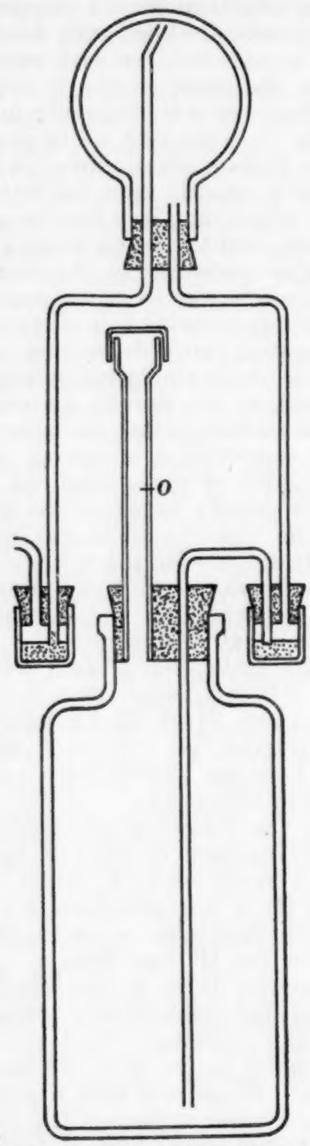

FIG. 2.—Livingston's orginal non-absorbing mounting with a spherical porous cup element. The spherical element mounted in Shive's manner is proposed as a future standard for this type of instrument.

This whole matter of standardization is obviously a drawback to the development of rational atmometry; if cups are truly different in their powers to supply water for evaporation, then—as has been emphasized—it is impossible to employ them for the comparison of different complexes of atmospheric conditions, for an alteration in these conditions can not be expected to affect the rate of loss from dissimilar cups in just the same manner. With the development of the porous cup the differences between them have been greatly decreased, so that it is now possible to procure a large number of cups all having the same coefficient. It is found in practice that it requires a very marked difference in the cups to render the coeffi-

[4] "The Plant World," Tucson, Ariz., announces that its office handles both the Livingston standard porous cup atmometer and the Livingston radio-atmometer.—C. A., jr.

cients inapplicable over the range of atmospheric conditions met with during the summer throughout the United States. Still further refinement will no doubt be attained in the future, but the instrument appears already to be amply precise for all the studies in which it has thus far been employed.

It should be remembered here that none of the atmometers employing imbibed solids are available for the study of evaporation in freezing weather. Pans of ice or of a nonfreezing solution are the only instruments thus far available for this important case of direct-measurement atmometry.

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THE INTRODUCTION OF METEOROLOGY INTO THE COURSES OF INSTRUCTION IN MATHEMATICS AND PHYSICS.

By CLEVELAND ABBE, Professor of Meteorology.

[An address delivered before Physics and Mathematics Sections of Central Association of Science and Mathematics Teachers, Chicago, Nov. 26, 1904.]

The study of meteorology has acquired a new and vivid interest since the establishment of fairly successful official weather forecasts in this country and Europe. The civilized world now knows that the weather and the climate, the winds and storms are controlled by rigorous laws of nature; we may not understand these laws as yet, but they are in control of the universe and we are to discover them and utilize them for the benefit of mankind. We have not yet found any limit to the attainments of the human intellect, and what the mind can do in the way of thinking the hand will find some means to attain in the way of doing. We must think out our work before we can do it.

The ultimate object of all our systems of education, elementary, collegiate, and post-graduate is to train the mind to think and then train the hand to do. In old times the schools crammed the brain with the results of work already done, memorizing a multitude of facts; but now, while not neglecting the memory, we seek to develop the reasoning faculties, or the reasoning habit of thought, and then to perfect our methods of doing. Our schools pay much attention to mathematics, mechanics, chemistry, and science in general, because these have an important practical bearing on our lives. In this movement toward the professional side of education meteorology has not been neglected altogether. I have been greatly pleased to see the enthusiastic reception accorded it in every part of the Union and its growing popularity in both graded and high schools. I suppose that we owe this specifically to the general success of the Weather Bureau, but more particularly to Prof. Wm. M. Davis, who established a school of meteorology about 1878 as a division of the school of geology at Harvard University. His students and textbooks, his Elementary Meteorology and the Climatology of his successor, Prof. R. DeC. Ward, and their methods of teaching have awakened teachers and professors alike to new possibilities. Other schools and other textbooks have come into existence. The elements of the subject are now so well provided for that I do not need to say more about this; but I do feel the need of further advances.

I regard meteorology not so much as a matter of observation and generalization as matter of deductive reasoning. Our studies have approached the limit of what we are likely to discover by inductive processes. We stand where astronomy stood in the days of Laplace. We have had our Galileo and Newton, but we still need other leaders, and you will all agree with me that these must be trained in the schools. They must get their first lessons from you. Twenty or thirty years hence our future masters in meteorology will tell how their feet were turned in the right direction by the teachers of to-day.

In every school I find several boys or girls that have taken a deep interest in the weather and its relations to our lives. They are often asking questions that bear upon it. They appear to observe and understand it better than others. These are they whom I would have you secure for the possible service of the Weather Bureau. There are others that often appear dull, but are not really so; their previous education has perhaps been imperfect, some one has confused their minds with erroneous ideas from which they can not easily rid themselves. There are others who have not yet awakened to a full interest in intellectual work. In general, the school will be benefited by taking up exact and experimental work as compared with inexact, indefinite, texts or phrases. We benefit a child more than we realize when we give him exercises in exactness. Why do we make him calculate interest to the last cent? Why practice the piano or singing until he can do it properly? Why draw or paint correctly? Why speak English precisely? Is it not our conviction that what is worth doing at all is worth doing

well? It is only the things that are well done that tell. Even in morals it is the bad thought that is the first step toward a bad act. So I wish to enforce the idea of teaching meteorology accurately, and to do this we must use accurate expressions and experiments, accurate figures and drawings, and correct mathematics. On the other hand, we enliven all mathematical and physical courses of instruction if we introduce into them applications to familiar subjects. The dullest student becomes alive as soon as he perceives that his distasteful mathematical tasks will help him to understand some subject that really interests him. There is no one, not even a child, that has not some favorite subject of thought, some one unanswered query, lurking in his brain. Find out what that is and you have found the keynote to which all his education may be made harmonious.

I know that the schools and colleges find so many subjects to teach and the hours of work are so taken up at school and at home that you will say it is out of the question to introduce another new study. However, I do not venture such a presumption, but would suggest a simple and practical scheme. The idea is simple.

When you are teaching mathematics or physics and seeking for examples illustrative of the application of these subjects, give special attention to meteorology and take your examples from the phenomena of the atmosphere. You may not at first find many cases, certainly there are very few in the books. You may have to draw upon your own reading and knowledge, or on the notes that you will find in the MONTHLY WEATHER REVIEW. But with a little ingenuity you will soon accumulate quite a goodly number of problems that will afford your students abundant food for thought.

I find that many take up mathematical physics as one of the courses leading to the various engineering professions, because the latter offer them a prospect of a good business for life, but occasionally one of these finds himself interested in the scientific or research aspect of the various problems as much or even more than in the engineering aspect. He will probably combine research with his business, if indeed he does not altogether relinquish the latter for the former, provided a favorable opportunity offers. Now, of such are the men from among whom the ranks of the future army of American scientists will largely be recruited, and if you find any such you will do well to help them develop their tastes for meteorology. They have studied mechanics, thermodynamics, steam engineering, electrical engineering, hydraulic engineering; they are graduates of our schools of engineering, they have also the very best foundation for research in meteorology, and their tastes incline in that direction. One can not expect to make any great advance in this science without having both a broad foundation, an inquiring mind, and great intellectual energy and perseverance.

If the colleges and universities are not yet ready to give meteorology an independent place, a professorship, an observatory, a laboratory, as they do for astronomy, chemistry, geology, and many other branches of knowledge, then the best temporary arrangement that we can make is to introduce it freely among the illustrative problems of the general courses in the fundamental mathematical, and physical studies of all exact science. But you will ask for some definite examples, and I have time to mention a few.

(1) Among the simpler applications of trigonometry are the various efforts made *to determine the altitudes and motions of the clouds.* The simplest method consists in determining the actual motion of a cloud by observing the perfectly parallel and equal movement of its shadow on the ground. One may stand upon an eminence and survey the landscape and with the help of a good map and the seconds hand of a watch or a simple seconds pendulum, may determine the direction of motion and the linear velocity of as many shadows as he wishes. If now at the same time he looks directly upward and observes the apparent angular velocity of a cloud as it passes the zenith, he will find that he knows the base and one angle of a right angled triangle, of which the other side is the cloud-altitude, which of course can then be computed by trigonometrical tables or, still better, by geometrical constructions. Trigonometry and geometry, arithmetic and algebra should all be kept at the finger tips ready for use by young students of science. Oftentimes a young man will stand in front of a theodolite or some other complex apparatus and feel that it is too much for him; some have their heads full of mathematics, but do not know what to do with it. The expert is the man who has the knowledge and can also do something with it. Our education should insist on the practical and quick utilization of every scrap of knowledge that we are the fortunate possessors of.

(2) Another ingenious application of geometry to the altitude of clouds is known as Feussner's method.[1] An observer stands at O and sees a shadow at K at a spot that he can identify on a detailed map of his surroundings. He recognizes that this shadow is that of a cloud at C and he therefore observes the apparent angular altitude of that cloud, which is the angle COK in the triangle. Now the angle CKO is the same as the apparent angular altitude of the sun, since a line drawn from O to the sun would be parallel to the line drawn from K through C to the sun. If, therefore, the observer measures the angle by which the sun is above the horizon or SOH, he then knows the base OK and the two angles at O and K and may compute or construct the vertical height of C above the horizon. There are several refinements to be thought of. K may not be on the same level with O; the cloud may have moved before he can observe its altitude and the sun's altitude, after having identified the shadow K as belonging to the cloud C. These refinements offer slight difficulties that may be overcome. If one has a correct watch he may simply observe the time when the shadow was at the point K and from that compute at his leisure the altitude of the sun.

(3) One of the oldest methods of determining the altitude of a cloud is known as Bernoulli's; the observer at O sees the cloud at C just as the last ray of the sun illuminates it. This last ray must have grazed the surface of the earth at some point W below the western horizon. By observing the time, we know at once the angle between the radii drawn to the earth's center from O and from W. This gives us the means of computing the distance from W to our vertical. But we also observe the apparent angular altitude of the cloud or the angle between OC and the vertical. We have now all the data needed to solve the problem. We have in fact three triangles to solve in succession. The problem becomes more complicated if we endeavor to allow for the refraction of the ray of light from W to C. I will not give the latter complex formula now, but may say that I hope to publish a long series of these problems in a little handbook[2] for the use of students and teachers and I think that you will not find them too difficult for most of your students. Authors of textbooks on trigonometry which give us many interesting problems suggested by the work of surveyors, navigators,

[1] **Feussner.** Über zwei neue Methoden zur Höhenmessung der Wolken. Ann. der Phys. u. Chem., 1871, 144: 456–467.

[2] This handbook has not yet appeared, May, 1915.—*Editor.*

and geodesists, seem to have quite forgotten that the clouds offer us still more fascinating problems.

(4) Some years ago the various weather bureaus of the world agreed upon a year of steady work on the altitudes of clouds. Some observers adopted the strictly trigonometric method of altitudes and azimuths. If a theodolite is placed at A and another one at B, the observers endeavor to sight simultaneously on a cloud at C. If they sighted on the same point at the same time and observed the altitudes and azimuths correctly, then it would seem certain that with AB as the base line they should be able to compute the linear distance of the cloud C and its altitude. But unfortunately a cloud has considerable size and there is never an absolute certainty that A and B observe the same point. Accordingly there arises a very interesting problem as to what points they have observed. Oftentimes calculations showed that the two lines of sight did not and could not intersect, so that the shortest distance between the two lines would seem to be the proper place for the cloud. You will find all the details of this problem in chance or the theory of errors, as it is called, in a report by Elkholm and Hagström.[3]

(5) During that same year other observers used what is called the photogrammeter or the nephograph, which is simply a photographic camera mounted with altitude and azimuth circles. Photographs are taken of the same clouds simultaneously and from these we may proceed by several methods. Either (I) we may measure from the photographic plate angular distances of various points in the clouds and determine the distance and dimensions of the whole cloud, or (II) we may proceed graphically, set the photographs up in a frame, reproducing as nearly as possible the original locations of the two cameras and then, using threads as lines of sight, carve out in the air of the room a small model of the cloud itself. This latter process was, I believe, first carried out in England under the supervision of Prof. G. G. Stokes, the eminent mathematician, who was at that time a member of the Meteorological Council at London. In fact, that council has often included some of England's most famous men and we are indebted to them for a number of important methods in meteorology.

(6) But perhaps the most fascinating as well as the simplest methods of *studying the clouds is by means of the nephoscope*. This is a very simple instrument, merely a circular mirror held horizontally; you look into it and see the cloud by reflection, which saves the trouble of twisting the neck in an uncomfortable position. The mirror has a graduated circle corresponding to the azimuth circle; its center is marked by a dot or cross lines and there are a few concentric circles drawn around that. At one side of the mirror is a light vertical rod holding a little knob, which may be raised or lowered and turned around to any azimuth so that when one observes a cloud reflected at the center of the mirror, he may so adjust the knob as to bring its image also at the center. But the cloud moves away and the observer must then move his eye so as to keep the knob covering the cloud until the knob and cloud disappear together at the edge of the mirror or cross some one of the concentric circles. In this process the knob is the center or intersection of two lines of sight, one from the cloud to the knob in its first position and again from the cloud to the knob in its second position. The horizontal path described by the intersections of these lines with the face of the mirror, is a miniature of the horizontal path described by the cloud in the time required by the images to pass from the center to the rim. We obtain thus the direction of motion of the cloud and a horizontal line that may be converted into the angular zenithal velocity.

(7) The prettiest application of this instrument and perhaps the most elegant of all methods of determining the height and velocity of the cloud, I have called the *kinematic method*. The idea is this: If we are in a boat or on a train, our motion is combined with the motion of the cloud. We seem to attribute our motion to the cloud and the observed line is a resultant movement, that you easily obtain by compounding movements or forces by the method of parallelogram of forces. If we move from A to B in the boat with our nephoscope it is as though the clouds move from B' to A' in the parallel but opposite direction, but if the cloud is actually moving from B' towards X, then the result that we observe is the line $B'X'$ as seen from the boat. This apparent angular motion we are to observe first when the boat is going from A to B and again when the boat is going in some other direction, such as B to C, or even when the boat is stationary, or when the boat directly reverses its movement, which we can most easily accomplish by carrying our nephoscope on a trolley or in a row boat on a canal. Now these two observations, together with the known velocities of the boat, give us four known terms in a pair of trigonometric equations from which by elimination we determine the altitude and the actual velocity of the cloud. The most difficult point is to determine the velocity of the boat and the method is therefore best adapted to give accurate results when the nephoscope is being carried by a steady steamer or by a car that is pulled by a cable, going at a perfectly uniform rate of speed in different directions, as for instance through the streets of a city.

(8) In the purely mathematical department, I happen to think just now of the so-called Poisson's equation relating to *the behavior of pure dry air when undergoing adiabatic changes*. This is given in some works on analytical mechanics and is mentioned in the elementary works on physics. But the good student will appreciate it better if you will give him the demonstration based on principles which may be made almost purely mathematical and fundamental

(9) When the same ideas are applied to the expansion and contraction of *moist air* with its changes from vapor into cloud and snow, we come upon a more complex problem in physics; but even this is so largely a question of pure mathematics that it may be included under that category, and I hope that you will make your scholars familiar with the elegant graphic methods introduced by Hertz, whose paper is fully translated in my "Mechanics of the Earth's Atmosphere"[4] and has been still more beautifully treated by Neuhoff in a German paper in 1900 but not yet translated.[5] Elaborate mathematical tables are given by Professor Bigelow in his "Report on International Cloud Observations."[6]

(10) The elementary textbooks on physics often mention the theory of the wet-bulb thermometer and its use in determining the moisture of the atmosphere, but they rarely give any satisfactory explanation of the process by which physicists have deduced the relation between the temperature of the wet bulb and the moisture in the air—that is to say, the rate of evaporation; the process is not so difficult but that anyone who has studied a little of the law of diffusion can understand it, and for brevity's

[3] Mésures des hauteurs et des movements des nuages, par N. Ekholm et K. L. Hagström. Upsal. 1884.

[4] **Abbe, Cleveland.** Mechanics of the earth's atmosphere. A [2d.] collection of translations. Washington, 1893. (Smithsonian misc. coll., 843). Pp. 198–211.

[5] This paper by **Neuhoff** has since appeared in English in—
Abbe, Cleveland. Mechanics of the earth's atmosphere, a [3d] collection of translations. Washington, 1910. Smithsonian misc. coll., v. 51, no. 43, pp. 430–493.

[6] **United States Weather Bureau.** Report of the Chief, for 1898–99. Washington, 1900. Vol. II. 787 p. 4°.

sake I must refer you again to my "Meteorological apparatus and methods."

Mathematics and physics go hand in hand so closely that we dare not think of separating them. If one experiments, he keeps the mathematical laws in mind; if he studies the subject mathematically, he keeps the physical laws in mind. A problem in one is also a problem in the other; both are rigorous and develop the reasoning powers; but sometimes it is easier to handle the experimental than the analytical method.

(11) In the MONTHLY WEATHER REVIEW for 1897 (pp. 296–302, 445) will be found a splendid memoir on the equations of hydrodynamics arranged for the study of the general circulation of the atmosphere. This and the corresponding solution of the complex differential equations give the mathematician more than he can handle at present, but the suggestive paper by MacMahon, read at the recent International Scientific Congress on the *n*-fold Riemann surface, opens up great hopes for the future.

(12) Meanwhile we must mingle experiment and theory; each must guide the other. The physicist may, in his laboratory, carry out some of the following experiments and at a glance perceive the resulting atmospheric motions that are equivalent to the solution of the differential equations under any given special conditions; the analyst would find it difficult to attain these but can easily confirm them when once the result is known.

We may experiment on small local motions before proceeding to the larger ones.

(13) In a large room or in a case with double glass walls, so that the inside temperature may be controlled, let a shallow stream of cool air flow along the bottom. By giving this a slight but adjustable slope the rate of flow may be regulated; by altering the bottom we may pass from water or smooth sand to wavy, rolling prairie or ranges of hills and mountains. We may imitate every variety of ordinary atmospheric motion.

By utilizing a layer of CO_2 for the bottom we may study the flow of upper air currents over lower ones.

(14) We make all these movements visible by introducing a little smoke, but especially by applying the so-called schlieren method of Foucault, as perfected by Mach and Dubois, which enables us to photograph the feeblest differences of density, whether due to pressure or temperature or moisture.

(15) Among other problems in aerodynamics should be mentioned that most elementary one, the hypsometric formula of Laplace. Our students and the surveyors and mountaineers use this with aneroids for determining altitudes without understanding its derivation or the sources of mistakes in applying it, especially the uncertainty of our knowledge of the temperature of the air. Now the formulas may be deduced analytically by integration of the simple differential formula or by algebraic or geometric or arithmetic or graphic methods, and all should be combined as an illustration of the unity of logic in whatever form presented. Science is but logic applied to material nature.

I will merely mention some other problems that appeal to us from both analytical and experimental points of view:

(16) The total resistance and the pressure and motions of the air all around a resisting plate, sphere, or other obstacle.

(17) The action of the wind in producing "suction" at the top of an open pipe or chimney.

Among problems that may be handled first by pure mathematics and then by experiment and observation are the determination of:

(18) The calibration correction of a thermometer.

(19) The protruding stem correction.

(20) The Poggendorff correction.

These belong to elementary physics but will give your students a chance to apply their mathematics to physical problems.

A complex trigonometrical problem involving a slight knowledge of astronomy is the determination of—

(21) The duration, and

(22) The intensity of sunshine or the total amount of heat received by a unit horizontal surface for any moment of the day and the year. The calculation is to be made for the outside of the atmosphere, because, if we attempt to make allowance for the absorption by the atmosphere the problem becomes too complex for elementary educational purposes. The simpler problem may be treated geometrically and graphically and is essentially a matter of familiarity with "the use of the globes" as it was called 100 years ago.

(23) Globes and charts are vital matters in meteorology and are elegant classics in geometry. *Chartography* and *projections* and *the globes themselves* are too much neglected—pushed aside by the crush of new demands for instruction in every other branch of knowledge, but these are absolutely fundamental to astronomy and meteorology, terrestrial physics, and all geographic relations. I hope to see them properly appreciated in the schools of pure mathematics and terrestrial physics. The properties and methods of construction of various equal surface projections ought to be as familiar to a student as those of the ordinary stereographic projection. The problems of chartography are beautiful for the drafting room but more vivid and better adapted to the comprehension of many persons if worked out on the globe itself—and one does not need an expensive globe—even a home-made globe or rubber ball can be very useful.

The globes and conic sections in solido should be handled by your students at some early stage in their education.

(24) Finally, to return to our aerodynamics. Nothing can be more attractive to a student than *the formation of a waterspout by* Weyher's method and the study of the wind velocity and pressure, the barometric pressure, the temperature, the vacuum, and the dimensions of the cloud column.

We simply set a horizontal disk at the top of a room or closed case into rapid rotation. Soon the air beneath is dragged into rotation down to the very floor. Below it we place a dish of water and the vapor from it is drawn up into the inner revolving vortex while at the same time thrown outward horizontally; eventually it descends and ascends in regular circulation. As the disk and air increase their rotary speed, the central vortex diminishes in barometric pressure while increasing in velocity, and the moist air flowing into it cools by expansion, forming a central waterspout column or vortex. Here we begin to be stirred with a desire to measure. We insert a long Pitot tube and determine the wind pressure at many points and chart the pressure or velocity on ruled paper. We insert a pair of small plane plates as in my method of barometric exposure (see Meteorological Apparatus and Methods), and determine and chart the pressure at many points. We send a thermometer or thermo-

electric junction exploring the vortex and plat the temperature, or we use some form of hygrometer and determine the dew points. In fact we experimentally determine all the elements that enter into the structure of the waterspout and compare our observations with the theories that have been worked out by Ferrel.

I have said enough for the present. I hope to elaborate this effort to help the mathematician and physicist find a new field full of problems for their students. Thus they will help us to develop the talents of future meteorologists.

These are but special illustrations of the general law that thinking, seeing, and doing must go together. We learn by doing as much as by reasoning—each helps the other. Every theory or hypothesis or suggestion should be reduced to exact formula, exact experiment, exact measurement. Precision is the vital essence of all valuable knowledge.

I hope to live to see special schools of meteorology, special laboratories, and mathematical seminaries devoted to this as to every other profession; but for the present at least I urge that you illustrate the value of and enliven the interest of your mathematical and physical courses by frequently quoting or proposing problems drawn from METEOROLOGY.

ON LIGHTNING AND PROTECTION FROM IT.[1]

By Sir JOSEPH LARMOR, F. R. S.

The rationale of electric discharge in a gas is now understood. When a small region becomes conducting through ionization by collisions in the electric field it should spread in the direction in which the field is most intense, which is along the lines of force. Thus the electric rupture is not a tear along a surface but a perforation along a line. This is roughly the line of force of the field; the electrokinetic force induced by the discharge, being parallel to the current, does not modify this conclusion. A zigzag discharge would thus consist of independent flashes, the first one upsetting adjacent equilibria by transference of charge. Successive discharges between the same masses would tend to follow the same ionized path, which may meantime be displaced by air currents.

If the line of discharge is thus determined by the previous electric field, the influence of a lightning conductor in drawing the discharge must be determined by the modification of this electric field which its presence produces. For a field of vertical force, such as an overhead cloud would produce, it may be shown that the disturbance caused by a thin vertical rod is confined to its own immediate neighborhood. Thus while it provides a strong silent discharge from earth into the air, it does not assist in drawing a disruptive discharge from above—except in so far as the stream of electrified air rising from it may provide a path. It is the broader building, to which the rod is attached, that draws the lightning: the rod affords the means of safely carrying it away, and thus should be well connected with all metallic channels on the building as well as with earth. It is the branching top of an isolated tree that attracts the discharge; a wire pole could not do so to a sensible degree. Separate rods projecting upward from the corner of a building do not much affect the field above it, but if they are connected at their summits by horizontal wires, the latter, being thus earthed, lift up the electric field from the top of the building itself to the region above them, and thus take the discharge which they help in attracting, instead of the building below them. Similarly, when the lines of force are oblique to a vertical rod, its presence does somewhat modify the field and protect the lee side; but generally the presence of a rod should not ever be a source of danger, unless the ionized air rising from it provides an actual path for discharge.

[1] *Reprinted from* Report British Association for the Advancement of Science, 83d meeting, Birmingham, September 10-17, 1913. London, 1914. Section of Mathematical and Physical Science, p. 387.

LIGHTNING INJURY TO COTTON AND POTATO PLANTS.*

By L. R. JONES and W. W. GILBERT.

[*Abstract* of a paper presented to the Sixth Annual Meeting of the American Phytopathological Society, Philadelphia, Dec. 29, 1914-Jan. 1, 1915.]

Literature contains meager data concerning lightning injury to herbaceous plants. The authors have evidence that such injury is not uncommon in certain crops, notably cotton and potatoes, and may occur in beets, tobacco, and ginseng. Grass, small grains, and corn seem less liable. Cotton and potatoes when so struck may be killed in roundish spots, 1 to 3 rods in diameter or sometimes several associated smaller spots. There may be no disturbance of soil or physical rupture of plant tissues. The plants near the center wilt, blacken, and die promptly; about the margins some may live days or weeks. Such weakened cotton plants yellow or redden. The injury appears first and worst from the soil line or a little above downward, but may not kill all the underground parts. Partially injured cotton plants may form callus ridges above point of injury and new potato shoots may sprout from base of injured stems. These various facts suggest the theory that when a sudden electric storm follows upon a period of dry weather, lightning discharge spreads horizontally over the moist surface layer of soil and that certain crops are more liable than others, either because of relative tissue resistance or because of character or distribution of aerial parts or root systems.

WEATHER AND HEALTH.

The Notices of the Imperial Academy of Sciences of Vienna for June 25, 1914, contain a brief statement of the results of a recent investigation of the important question as to the connection between weather and human health, undertaken by Dr. Ernst Brezina and Wilhelm Schmidt at the Austrian Central Meteorological Institute in Vienna and presented to the Academy on June 14, 1914.[1]

Heretofore, as the authors showed, this question has been treated largely if not entirely from the standpoint of the physiologist; therefore it seemed all the more promising to follow more the methods of meteorology and to subdivide the weather more minutely into its elements, thus of course adopting a purely statistical method of treatment.

An unprecedently large and explicit series of meteorological elements, from the records of the Central Meteorological Institute, were compared by a specially appropriate method, day for day, with a series of daily values which presented in a somewhat quantitative manner the condition and behavior of extensive groups of healthy and ill persons. For the present investigation Brezina and Schmidt employed: (1) Records of the average hourly work accomplished by a large number of female employees of the Imperial Census Commission, in punching the counting cards (Zählkarten) (*light mental office work*); (2) the recorded daily number of epileptic attacks (i. e., number of patients affected) among the inmates of the hospital for mental and nervous diseases "Am Steinhof" (*condition of the sick*); (3) daily general estimates of the per-

* *Reprinted by permission* from Phytopathology, No. 6, December, 1914, 4: 406.
[1] *Summarized in* Meteorologische Zeitschrift, Braunschweig, Jan. 1915, 32: 43-44.

formances of the scholars in 60 classes of the Vienna public schools (*mental work of children*).

The carefully worked out results of this extensive investigation were presented in over 100 tables. The most important conclusions may be stated as follows:

1. If the weather exerts any influence at all its effects are restricted to relatively narrow limits.

2. Easy mental work is best carried on under only slight daily pressure changes.

3. Under rapid pressure changes (having periods of 4 to 20 minutes) there was a pronounced falling off in work accomplished, and a poorer condition in patients.

4. Higher temperatures and temperature variations, particularly those of a two-day duration, caused a falling off in mental work; while epilectics seemed to be sensitive to cold.

5. Correlation with other meteorological elements was generally less definite or quite impossible; the latter was particularly true for the quantity of ozone present.

6. If one desires to make use of the usual weather-descriptive methods it appears more desirable to select the isallobaric regions (those of rising and falling pressures) rather than the favorite isobaric regions of highs and lows. The isallobaric regions showed pronounced synchronal relations in all cases, even in the studies of the school children where the other relationships were rather indistinct.

The material collected has been but partially studied so far, and the results here summarized apply only to Vienna in 1912.

The methods employed revealed, of course, only a chronological relationship; direct effects could not be traced here even as well as they might through physiological experiments. However, although these methods do not by any means permit one to unravel the true causes of the phenomena by means of the merely accidental or essential concurrent circumstances, nevertheless these methods have the advantage, among other things, of broad foundations in every direction, of working under natural surroundings and the possibility of summarizing conditions that can not be directly realized in an artificial experiment. Disregarding even these advantages, these studies offer a guide to the direction in which results may be properly sought for in the future.

HUNTINGTON ON THE CLIMATIC FACTOR.[1]

By W. J. HUMPHREYS, Professor of Meteorological Physics.

This latest book by Prof. Huntington, of Yale, fully supports his reputation as a persistent worker, resourceful advocate, and delightful writer. As the title of the book indicates, climatology is the main topic, not climatology as a disconnected and isolated science, but climatology in its relation to and as interpreted by geology, botany, archeology, and ethnology.

Everyone must admit that climate is an important factor in a thousand things, some of which, like the age and growth of trees, the size and course of rivers, the area and depth of lakes, and even the development of nations and the evolution of the human race have accumulated innumerable and invaluable records; fragmentary to be sure, and hard to interpret, but never biased and, taken together, covering every age from the very present to the earliest geologic aeon. It is some of the more conspicuous of these records that Prof. Huntington and others, at the expense of a great deal of labor, have brought together and discussed in the book under review. For the data themselves we must be thankful. No climatologist whose vision extends beyond yesterday's meteorological records can afford to ignore them. In regard, however, to any climatic hypothesis one may fashion to fit the observed facts it is necessary to be conservative and cautious. Of course, a working hypothesis is often a great help to progress, and Prof. Huntington has wisely been bold enough to further his own work in this way. He assumes that during historic times there have been a number of extensive, probably world-wide, climatic changes, especially changes in the amount of precipitation; that they were irregular in occurrence, intensity, and duration; and that some of them lasted several centuries. This is certainly a good working hypothesis and the author legitimately and cleverly endeavors to support it with data from a number of independent sources. The big trees of California, for instance, are as independent of the Maya ruins of Yucatan as of the rings of Saturn, and yet in the hands of Prof. Huntington the Maya ruins and the big trees tell the same tale of centuries-long climatic changes. But in spite of all this cumulative evidence the author is frank enough to say of his hypothesis (p. 224), in the open-minded spirit of the true investigator:

> Doubtless it will be further modified; doubtless I have ascribed to it some results really due to other causes; but that is an inevitable stage of a new subject. The only question is: How far does the present theory harmonize with the great body of facts by which it has been or may in future be tested? So far as it does so, we may tentatively accept it. So far as it does not, it must be rejected.

Surely this statement is fair enough to disarm any combative opponent.

But to be more specific and more critical:

The interesting fact, discussed on pages 12 and 13, that in southern Arizona at high altitudes winter precipitation is greater than that of summer while at low altitudes it is less than that of summer does not seem to the reviewer to indicate, as suggested, any climatic peculiarity or to be at all mysterious. The winter precipitation in Arizona, as elsewhere, is largely the result of topographic deflections of otherwise horizontally moving winds, and hence is greatest at considerable altitudes. On the other hand, the summer precipitation is due almost wholly to the strong vertical convection of thunderstorms whose formation is especially favored by the high temperatures of the valleys and plains. In short, the phenomenon in question appears to be fully accounted for by the difference in the summer and winter processes of inducing precipitation; that is, topographic deflection and heat convection.

On page 90 it is stated that "the more severe climatic changes of the present time appear to be, in general, synchronous in the United States and Europe. This was evident in the summer of 1911, when England was so dry as to be changed from a green land to a brown, and the eastern United States had the hottest, driest season for a century." The first statement, that in general the climates of Europe and the United States vary together, is true, but the data for the single year 1911, or any other, is no proof of it. Besides, the statement that during the summer of 1911 "the eastern United States had the hottest, driest season for a century" may need some modification, in the light of the accompanying table made up from Weather Bureau records. Instead of that season being the "driest for a century," it appears actually to have been wetter than usual.

[1] The Climatic Factor as illustrated in arid America. By **Ellsworth Huntington**, with contributions by **Charles Schuchert, Andrew E. Douglass**, and **Charles J. Kullmer**. Washington, 1914. vi, 341 p. 12 plates, 2 maps, 90 text cuts. 4°. (Carnegie Institution of Washington, Publ. No. 192.) $5.50.

Departures of temperature and of precipitation from their normals, 1911.

Month.	New England.		Middle Atlantic States.	
	Temperature departure.	Precipitation departure.	Temperature departure.	Precipitation departure.
	°F	Inches.	°F	Inches.
July	+3.3	−0.3	+1.6	−1.2
August	+0.2	+1.2	+1.1	+3.3
September	−0.8	−0.5	+1.6	−1.3
Season	+0.9	+0.1	+1.4	+0.2

Chapter XI, "A method of estimating rainfall by the growth of trees," by A. E. Douglass, is quite the best discussion of this subject known to the reviewer. For a number of years Prof. Douglass has studied minutely and exhaustively the relation of the growth of trees, as shown by the nature and size of their "annual" rings, to the cotemporaneous weather in their immediate neighborhood. With both records, tree growth and weather, before one, the relation between them seems to be clear and obvious, and may justify Prof. Huntington in applying the same method to the big trees of California.

There is, however, great difficulty in interpreting the sequoia records. Though one ring, and that a ring all the way round, for each year is the rule there are many exceptions. Under the influence of certain conditions, especially of the seasonal distribution of precipitation, two rings may be deposited during a single year. On the other hand conditions occasionally obtain that permit but little if any annual growth. In addition to all this the records are still further complicated by the fact that the rings often are so fragmentary that one side of a large sequoia may register an age centuries greater than another side. Surely then the interpretations must be difficult. But even so the sequoia's weather records are valuable because, among other reasons, they are continuous for the same locality through the remarkable period of more than 3,000 years.

"The Shift of the Storm Track," by C. J. Kullmer (pp. 193–205), is a valuable contribution to climatology. It shows that the average storm track across the United States had practically the same location during 1899–1908 that it had two decades earlier, or during 1878–1887. According to the record the average storm track was a little farther south and a little farther west during the later than during the earlier period. It does not follow, however, at least it does not appeal to the reviewer as following, that there actually was a shift in the position of the average storm track. Many additional Weather Bureau stations were established during the interval between the two selected decades, and while those added in the East were relatively close together, and therefore could not materially have modified either the number of storms reported or their observed locations, the stations added in the South and West were widely scattered and must have altered both factors.

This consideration does not in the least detract from the value or excellence of Prof. Kullmer's paper, but it does seem to estop the assumption that any definite shift in a decade average path of storm tracks has, in this case, been actually observed.

On page 232 it is stated that "climatic changes are due primarily to a strengthening or weakening of atmospheric circulation." A strengthening or weakening of atmospheric circulation would, of course, be a climatic change within itself and would induce still other changes. It would seem better, however, in seeking a primary cause of climatic changes, to go back at least one more step to changes in temperature and temperature gradients, for temperature and temperature differences are at the bottom of all weather and all weather changes.

On page 234 the inception of the carbon-dioxide theory of the ice ages is, as usual, ascribed to Arrhenius. It may indeed have been entirely original with Arrhenius but, as a matter of fact, Tyndall suggested the same idea at least 35 years earlier.

On page 250 it is stated that "when the growth of a century or two is considered the trees are found on an average to grow relatively fast when the sun spots are at a maximum and slowly when they are at a minimum." Elsewhere (figs. 17 and 42, for instance) we are assured that in general tree growth and rainfall vary together and in the same sense. The inference, therefore, is that with maximum sun spots there is maximum rainfall and with minimum spots minimum rainfall.

Now, the fact that the average temperature of the entire world, or even of a single continent or broad zone, if not modified by some such accident as a veil of volcanic dust, is highest during spot minima and lowest during spot maxima is almost as definitely established as is the obvious fact that the average temperature of summer is higher than that of winter. This higher temperature must imply greater evaporation and also greater precipitation for the world as a whole; and, so far as studied, the records appear to support this conclusion. As most trees examined seem to contradict this conclusion, while those of Arizona confirm it (see Huntington's fig. 24), it therefore would appear that the influence of other climatic factors on tree growth, the importance of seasonal distribution of precipitation and of local peculiarities all combine to make it impossible to infer from the trees of a small number of places more than the broadest generalities about the climates of the past. But even this, and Prof. Huntington claims no more, is distinctly worth while.

The solar hypothesis as developed in Chapter XIX, the assumption that changes in the solar constant have been coincident with and the chief causes of all climatic changes, including those of the glacial and interglacial epochs, frankly does not appeal favorably to the present reviewer, and Prof. Huntington by his commendable courage to follow this hypothesis to its logical conclusion has rendered its acceptance vastly more difficult. On page 261 he says: "With them [solar changes], however, and perhaps *inseparable*[2] from them, occur changes in the earth's interior whereby crustal deformation is induced."

Probably to most people this will appear as a reductio ad absurdum, and therefore a compelling reason—if they accept the apparently sound logic upon which it is based—for abandoning altogether the solar hypothesis of great climatic changes, such as undoubtedly occurred time and again during the geologic past.

The final chapter (pp. 265–296), "Climates of Geologic Time," is by Charles Schuchert, a master of this subject. It presents no obvious ground for criticism and even praise would be superfluous.

To sum up: The book, as a whole, is excellent. It will interest many people and some, the climatologist among them, must study it carefully. Whether the conclusions are accepted or rejected, the evidence can not be wholly ignored. Doubtless some day extensive revisions will be needed—and made—for the subject is new and the conclusions confessedly only tentative. The book should be carefully read. It abundantly deserves it, but read as the author would have it read, with mental reserve and discrimination. Nor should it be forgotten that the subject of climatic changes has two sides, a pro and a contra.

Those who wish both sides will find the contra well summed up by Prof. Gregory,[3] under the caption "Is the Earth Drying Up?" The pro side is new; its ablest exponent, Prof. Huntington; its best defense, the book under review.

[2] Italics are the reviewer's.
[3] Geographical journal, London, Feb., Mar., 1914, 43: 148-172, 293-318.

SECTION III.—FORECASTS.

PRESSURE DISTRIBUTION DURING MARCH, 1915.

By ALFRED J. HENRY, Professor of Meteorology.

[Dated, Weather Bureau, Washington, Apr. 16, 1915.]

The continued interruption of meteorological reports from European and Asiatic countries makes it impossible ascertain at present the pressure distribution over the greater part of the Northern Hemisphere during March, 1915. Available reports, however, show that the pressure for the month was about 0.35 inch below normal at the Azores, about 0.20 inch below normal at Bermuda, and 0.50 inch below at Sydney, Nova Scotia. The latter departure, together with reports received daily from the Canadian Maritime Provinces and adjacent portions of the United States, all clearly indicate that the North Atlantic was occupied by a deep depression. How far eastward it extended is problematical, although we might infer from the low pressure over the Azores that the pressure was high over Iceland.

In the central Pacific, as at Honolulu, pressure was practically normal. In interior Alaska pressure was very slightly above normal, but on the coast practically normal values prevailed. Hence we must infer that so far as Pacific and Alaskan pressures are concerned normal March weather in the United States should have been expected. On the contrary, the weather of the month, as controlled by the tracks of highs and lows, was indeed far from normal. The abnormality consisted of a preponderance of west winds over northeastern districts, a very general deficiency in the rainfall and almost unprecedented cold in the southwest.

The preponderance of westerly winds is clearly the result of the marked depression of the barometer over the northern Atlantic, as already mentioned; likewise the dryness is closely associated with the same cause.

The tracks of highs and lows are set forth as usual in Charts II and III, respectively, to which special attention is directed. Chart II, Tracks of Centers of High Areas, shows that there was a marked congestion in the tracks of highs over the Missouri Valley and thence southeastward to the Gulf and Atlantic coasts. The chart also shows a remarkable absence of highs over the northeastern part of the country north of latitude 40°; also that the main drift of the highs was southeastward rather than eastward; and, finally, that the level of the barometer in the highs sank rapidly as the highs advanced to the eastward.

Considering now the tracks of the centers of the lows, Chart III, we observe (1) a remarkable absence of North Pacific and Alberta lows, or of lows that ordinarily move eastward along the northern circuit; (2) we also note the entire failure of lows to move across the Missouri and upper Mississippi Valleys; and finally (3) that the lows, of which there were an average number, were confined almost wholly to the southwestern Plateau region of Nevada, Utah, Colorado, northern Arizona, and New Mexico. Only one of the lows (No. 1) attempted to cross over to the northern circuit, and that attempt was a failure by reason of the intervention of a marked high (No. 2 of Chart II). But perhaps the most interesting feature of the movements of highs and lows was the avoidance by the lows of the snow-covered region of the middle Missouri Valley and the congestion of the highs in the same region.

It is well known from the studies of Voeikov [1] that snow does not thaw, or thaws very little, under the direct influence of the sun's rays so long as the air temperature is below freezing; therefore snow melting in general begins only when a mass of warm air from a snow-free land surface or an ice-free sea has raised the air temperature above freezing. The ground in Nebraska, South Dakota, and adjacent portions of the surrounding States was snow covered during practically the whole of the month. This of itself is a rare event, but the influence of the snow covering on the building and maintenance of highs was of especial interest to the forecasters. I have selected the station at North Platte, Nebr., latitude 41° 8′ N., longitude 100° 45′ W., as representing the snow-covered region; and Fort Wayne, Ind., latitude 41° 5′ N., longitude 85° 10′ W., as representing the snow-free region. The mean maximum temperatures during March, 1915, were as follows: North Platte, 34.1°F., Fort Wayne, 40.1°F.; mean minimum: North Platte, 19.4°F., Fort Wayne, 25.1°F.

Thus we perceive that the temperature conditions in the snow-covered region, even during the warmest part of the day, were but a few degrees above freezing, and thus the great congestion of highs in the snow-covered region is explained. Moreover, we feel justified in putting forth the opinion that the continued low surface temperatures and anticyclonic conditions acted as a bar to the entrance of lows into the region. Why lows did not originate in Alberta or the North Pacific and move eastward along the northern circuit, however, remains to be explained.

Considering the marked diminution in pressure over the North Atlantic, we would remark that the pressure relations over the continent to the westward of any deep oceanic depression are not the same as under normal pressure distribution. Thus the probability of precipitation over New England from barometric depressions approaching from the west is very considerably reduced and the duration of the precipitation is very much shortened. It is readily seen that, so long as the oceanic depression continues, New England is under the domination of west winds and the conditions for precipitation are unfavorable. A fresh depression from the west serves merely to disturb temporarily the existing pressure conditions and is immediately swallowed up in the greater oceanic low. The most puzzling condition, however, is the avoidance of the northern circuit by the highs. Ordinarily a low is almost immediately followed by a high; in fact, one of the precepts developed by empirical weather forecasting is the necessity of having a path for the high prepared in advance, so to speak, by the passage of a low. But here we have a vast depression that may continue for a month and not a single high from the west moves into the region of deficient pressure except in a round-about way from the southwest. See also the pressure distri-

[1] Penck's Geograph. Abhandlungen, Band 3, Heft 3. Wien, 1889.

bution and the tracks of centers of highs in February, 1902; December, 1903; January, 1903; and February, 1901.

CONTROL OF MARCH WEATHER BY PRESSURE DISTRIBUTION.

In this connection we wish to refer to a very comprehensive discussion of the subject by Dr. O. L. Fassig,[2] also to a paper by Prof. W. J. Humphreys entitled "Warm and Cold Winters of the Eastern United States" (this REVIEW, December, 1914). Prof. Humphreys, however, does not give the continental pressure distribution in his paper; therefore his charts and discussion are only partly applicable to the temperature distribution over the eastern United States. While low temperatures over northeastern districts are undoubtedly due in part to oceanic pressure distribution, the low temperatures of March, 1915, were most pronounced in Texas and the Southwest. Indeed, the temperature over a small part of New England was slightly above the normal, notwithstanding the persistence of continental winds.

In order to produce abnormal cold in the eastern part of the United States a necessary concurrent condition, in addition to the development of a great depression over the North Atlantic, is that highs shall move eastward along the northern circuit, as in February, 1904. This is equivalent to saying that the continental high shall be developed farther to the northeast and east than in normal years.

Low temperatures of the Southwest resulted from the unusual development of the continental high over the Missouri Valley and the Plains States to the south; whereby northerly winds prevailed during a large portion of the time.

Forecasts and warnings for the month were made by Prof. H. C. Frankenfield.

[2] Fassig, Oliver L., in Amer. jour. sci., New Haven, (4) 1: 319-340.

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, MARCH, 1915.

By ALFRED J. HENRY, Professor in charge of River and Flood Division.

[Dated: Washington, D. C., May 1, 1915.]

A single rainstorm, that of March 3–6, caused floods in the rivers of Arkansas, also in the Red River at Fulton, Ark., and in the streams tributary to the Red in western Arkansas. The Arkansas River was slightly above the flood stage at one or two points along its course through Oklahoma and Arkansas; however, little damage was sustained. The same storm, in passing across the Carolinas, caused moderate floods in the rivers of South Carolina. The loss sustained in South Carolina and in Arkansas appears in the small table below.

Loss from floods, March, 1915.

State or district.	Bridges, highways, etc.	Live stock.	Loss of land by caving banks.	Value of warnings.
South Carolina	$200	$222	....	$15,780
Red River	17,400	7,000	$12,000	45,500

SNOWFALL AT HIGH ALTITUDES, MARCH, 1915.

[As summarized from the reports of Section Directors.]

Arizona.—There was heavy snowfall in the mountain districts early in the month, followed by unsettled weather with occasional lighter falls throughout the first decade. It held cold after the storms of February until near the middle of the month. For this reason the accumulated snow of February and March settled but little and was much drifted. The packed snow was chiefly that remaining from the storms of earlier winter months. By March 10, at altitudes above 7,500 feet, the snow had reached greater depths than had been known in many years, if ever before since settlement by whites. This was attributable both to the usual storms of February, supplemented by the fall during early March, and the persistent cold weather. With bright warmer weather there was much daytime melting during the last half of March. Below 7,500 feet the snow disappeared rapidly. Between 8,000 and 9,500 feet, while there was a marked decrease in actual depth there was but little loss in water content. At the close of March there was more snow at high levels than for many years past, all streams were running fairly full from the melting at moderate levels.

California.—The snowfall in the mountains during March, 1915, was very light except in portions of southern California, where average amounts were reported. The deficiency was marked in the Sierra Nevada and Siskiyou ranges. The heavy snow of the preceding months was well packed and there was very little run-off, leaving at the close of the month more than the average amount of solid snow on the ground at the higher levels. All reports showed a large amount of snow in the higher mountains, which at this time of the year would indicate an ample supply of water for irrigation and power purposes.

Colorado.—Weather conditions during March were not favorable to a material increase in the amount of snow at high elevations. As compared with the normal, the snowfall for March was deficient throughout the western counties and the mountain region, except in the vicinity of Longs Peak. The deficiency was marked on the Rio Grande and San Juan watersheds, and over a considerable area on the Gunnison, Grand, and northwestern watersheds. A marked deficiency also occurred at the head of the Arkansas. The streams were higher than common, as frozen ground prevented the taking up of the usual amount of moisture.

At the end of March the average water equivalent of the snow and the water equivalent at the corresponding date a year ago were, respectively, as follows: South Platte watershed, 2.06 and 5.30 inches; North Platte, 4.27 and 4.90; Arkansas, 3.90 and 4.10; Rio Grande, 3.93 and 4.90; Grand, 4.59 and 6.50; Gunnison, 5 and 7.20; Yampa, 5.41 and 6.60; and San Juan, 4.22 and 3.40

Idaho.—Following an unusually dry summer, the winter of 1914–15 was the driest on record for Idaho; the precipitation for the five-month period ending March 31 amounting over the State to but 5.73 inches. The forepart of the winter was cold; hence the snow falling in that period was light and dry. February and March were abnormally mild, with most of the precipitation in the form of rain. The average snowfall for March was the least on record, and, except over small areas, there were no material additions to the snow supply during the month. The continued mild temperature caused the snow to disappear except in the higher mountains, but no high water was experienced. The outlook is for a small flow of water during the season.

Montana.—March was the fifth successive month with deficient precipitation throughout the State and deficient snowfall in the mountain districts. The average precipitation for the State for this period as a whole was the least during the last 20 years, and it is the consensus of opinion of foresters, miners, and others familiar with snow conditions this year and in the past that there was less snow in the mountains at the close of March than for many years. This deficiency is somewhat accentuated by the fact that the year 1914 was generally deficient in precipitation.

Nevada.—This month's snowfall was greater than that of March, 1914, yet as compared with the normal there was deficiency ranging from 62 per cent in the Carson Basin to 81 per cent in the Walker Basin. At the close of the month there was less snow on the ground than usual, except at Tahoe, Cal., where it was normal. The accumulated winter's snowfall had practically disappeared by the 31st at most stations except in the Truckee Basin. The prospects for an ample water flow next summer in the Truckee Basin are good.

New Mexico.—There were general and frequent snowstorms during the first 20 days of March, along with much cold, cloudy, favorable weather, although the gradual advance of the season settled and melted the snow considerably. The average fall for the State was more than 11 inches, an amount that brings the seasonal fall up to 38.4 inches, nearly twice the normal. The clear, warm

weather of the last decade caused rapid melting and settling, and little snow remained below the 7,000-foot level at the end of the month. The highest districts showed a decrease of nearly one-half in the stored depth, indicating the loose character of the snow and its early passage into the streams of the State.

Oregon.—During every month of the past winter the snowfall was less than the average, and in many places it was less than the amount in any one of the last 10 or more years. December and January were cold months, having protracted periods with east winds, and the snow that fell had a small water content. February and March were mild months, and the water content of the snow was good, but the amount was small and much melting took place, so that at the end of March none was left except at high altitudes, and some of the southern slopes at relatively high altitudes were bare of snow. There will be a shortage of water for irrigation and placer mining during the late spring and early summer, and spring freshets will be of short duration.

South Dakota.—The average snowfall at 21 stations in the elevated regions of South Dakota—that is, the Black Hills region of the State—was 11.9 inches, which is about normal; however, there was a marked difference between the various amounts recorded. In parts of Lawrence and Fall River counties the accumulated amount for the month was nearly 2 feet, while in parts of Butte and Custer counties it was less than 4 inches. The average depth of snow on ground on the 15th was about 7.5 inches and at the end of the month about 7 inches. These amounts are somewhat smaller than at the corresponding times in February. The snow generally was packed very hard, and consequently contained much water. There will apparently be an ample amount of water for irrigation purposes. The streams were generally frozen over.

Utah.—In the Great Salt Lake watershed only a few correspondents reported that the snow stored in the mountains was equal to the average amount; most correspondents reported that the snow was unusually short and that the prospects were for a dry season if the irrigating water was not supplemented by rain during the summer. A very careful snow survey of City Creek Canyon showed that there was one-third less snow there than last year and that the snow was in condition for early melting.

In both the Sevier Lake and southern portion of the Colorado River watersheds the outlook was very promising, and some observers reported that the creeks were already bank full. A shortage was reported in the Green River watershed.

In the national forests of the State the snow was below normal in most places and in a favorable condition for early melting.

Washington.—The snowfall in the mountains and elevated valleys for the month of March was unusually light and was the least on record for this section. The month was remarkably mild in temperature and there were warm rains on the slopes and in the valleys. Hence the snow melted rapidly and by the middle of the month it had gone from the valleys and southern slopes, and at the end of the month there was no snow except on the summits, wooded northern slopes, and where it was packed in draws and gulches.

Wyoming.—Snowfall during the month of March was irregularly distributed. Depths on the watersheds of the Big Horn, North Platte, Powder, and Yellowstone rivers were substantially increased. No change in depth occurred on the watersheds of the Green, Snake, and Tongue rivers, while on the Cheyenne River and in the Yellowstone Park less snow lay on the ground than at the end of February. While the mean temperature for the month was below normal, there were many days on which melting occurred to a marked degree. The run-off was inappreciable, and subsequent freezing improved the condition of the snow for slow melting. Except for local irrigation, indications point to less than the normal amount of water from all watersheds. A marked deficiency is indicated for the Snake River and all streams taking their rise in Yellowstone Park.

MEAN LAKE LEVELS DURING MARCH.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Apr. 6, 1915.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during March, 1915:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	601.50	579.57	571.37	245.27
Above or below—				
Mean stage of February, 1915	−0.20	−0.01	−0.04	+0.28
Mean stage of March, 1914	−0.42	−0.41	−0.11	−0.40
Average stage for March, last 10 years	−0.13	−0.56	−0.38	−0.63
Highest recorded March stage	−0.78	−3.38	−2.48	−2.54
Lowest recorded March stage	+0.84	+0.46	+0.54	+0.97
Probable change during April, 1915	0.0	+0.3	+0.7	+0.6

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR MARCH, 1915.

By W. J. HUMPHREYS, Professor of Meteorological Physics, in charge of Seismological Investigations.

[Dated, Weather Bureau, Washington, D. C., Apr. 28, 1915.]

TABLE 1.—*Noninstrumental earthquake reports, March, 1915.*

Day.	Approximate time Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
	H. m		° ′	° ′			*M. s.*			
1	17 15	Brawley	32 59	115 40	4	1		Rumbling		M. D. Witter.
4	12 50	Julian	33 05	116 37	5	1	8	Rumbling		J. H. L. Vogt.
12	14 00	Cahuilla	33 32	116 43	4	1	2	Rumbling		Dr. W. L. Shawk.
17	3 25	Arbolado	36 15	121 47	3	1	1	Rumbling		Forest Service.
19	19 04	Rialto	34 12	117 27	2	2	4			So. Cal. Edison Co.
29	13 40	China Flat	40 56	123 30	1	1	3			O. I. Westerburg.
30	18 00	Brawley	32 59	115 40	1	1				M. D. Witter.
		IDAHO.								
15	3 35	Montpelier	42 20	111 17	5	1		Rumbling		Forest Supervisor.
		MICHIGAN.								
3	7 45	Calumet	47 13	88 26	3-4	1		Rumbling	Mine caving in?	E. S. Grierson.
		MONTANA.								
4	15 00	Lytle	48 01	111 26	3	1	30	Rumbling		J. F. Fait.
4	8 30	Shelby	48 30	111 55	2	1	4			O. C. Fjeld.
		WASHINGTON.								
1	3 00	Lakeside	47 50	120 00	3	1				W. H. Van Meter.
6	5 10	Lakeside	47 50	120 00	1	1				W. H. Van Meter.
6	5 30	Lakeside	47 50	120 00	4	1	5	Rumbling	Shook buildings	W. H. Van Meter.
		WYOMING.								
31	18 30	Bedford	42 56	110 56	4	1	8	Rumbling	Shook buildings	C. G. Heiner.

TABLE 2.—*Instrumental reports, March, 1915.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols see this REVIEW, December, 1914, p. 689.]

Arizona. **Tucson. Magnetic Observatory,** U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: E: V 10, T_0 16; N: V 10, T_0 19.6

Date.	Character.	Phase.	Time.	Period. T	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Mar. 5		e_N	4 23 06	6				
		e_E	4 22 46	10				
		M_N	4 25 04	8		100		
		M_E	4 23 36	10	30			
		C	4 28 00	6				
		F	4 39 00	6				
28		P_E	19 52 07	2				
		P_N	19 52 10					
		L_E	19 55 22	5				
		L_N	19 56 23	3				
		M_E	19 57 08	6	30			
		M_N	19 57 23	4		20		
		C	20 02 00	5				
		F	20 10 00	3				

Colorado. **Denver. Sacred Heart College.** Earthquake Station. A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Mar. 1			7 51 —					Minor earthquake at Grand Junction, Colo. Very slight tremors recorded.
			7 52 —					
3			9 59 —					Slight sinusoidal curve, but not regular.
			10 00 —					
5			23 59 —					Very small, irregular waves, especially on N-S, recurring several times during the day.
6			0 06 —					
6								Activity; thickening of penmarks; possibly connected with quake reported from Abruzzi Provinces, Italy.

TABLE 2.—*Instrumental reports, March, 1915*—Continued.

Colorado. **Denver. Heart College.** Earthquake Station—Contd.

Date.	Character.	Phase.	Time	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.				*Sec.*	μ	μ	*Km.*	
Mar. 13	......	....	18 39 —	....	....	....	......	Very strange record of broken waves especially strong on N-S.
			18 45 —	....	....	....	......	
			18 45 —	....	....	....	......	
			19 00 —	....	....	....	......	
24	......	....		....	....	....	......	Activity; thickening of penmarks at times during the day.

District of Columbia. **Washington. U. S. Weather Bureau.**

Lat., 38° 54′ N.; long., 77° 03″ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

Instrumental constants.. V 110, T_0 6

Date.	Character.	Phase.	Time	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Mar. 5	......	e_N....	4 34 36	4	....	....	......	No distinct maximum.
		L_N....	4 35 47	10	....	....	......	
		F....	4 47 00	....	....	....	......	
20	......	e_N....	22 34 47	....	....	....	......	Beginning uncertain.
		L_E....	22 45 01	....	....	....	......	Phases doubtful.
		F....	22 51 00	....	....	....	......	

Hawaii. **Honolulu. Magnetic Observatory.** U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instrument: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant.. T_0 18.9

Date.	Character.	Phase.	Time	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Mar. 5	......	e......	4 37 42	23	....	....	......	
		M......	4 41 42	....	400*	....	......	
		C......	4 51 00	....	....	....	......	
8	......	P......	15 47 12	....	....	....	......	
		L......	15 56 30	22	....	....	......	
		M......	15 59 48	....	400*	....	......	
		C......	16 51 06	....	....	....	......	
		F......	16 45 30	....	....	....	......	
10	......	P......	1 09 42	....	....	....	......	
		L......	1 25 54	23	....	....	......	
		M......	1 30 42	....	300*	....	......	
		C......	1 34 12	....	....	....	......	
		F......	2 09 48	....	....	....	......	
11	......	e......	16 36 06	24	....	....	......	
		M......	16 39 48	....	200*	....	......	
		C......	16 45 00	....	....	....	......	
		F......	16 50 00	....	....	....	......	
11	......	P......	18 25 30	....	....	....	......	
		L......	18 34 00	22	....	....	......	
		M......	18 41 12	....	800*	....	......	
		C......	18 52 54	....	....	....	......	
		F......	19 17 06	....	....	....	......	
12	......	P......	15 08 42	....	....	....	......	
		S......	15 15 42	....	....	....	......	
		L......	15 24 42	24	....	....	......	
		M......	15 33 54	....	800*	....	......	
		C......	15 46 30	....	....	....	......	
		F......	17 31 00	....	....	....	......	
17	......	e......	19 01 54	....	....	....	......	F occurred during daily attention to instrument.
		M......	19 02 54	20	400*	....	......	
		M......	19 16 06	20	400*	....	......	
		C......	19 21 06	....	....	....	......	
18	......	e......	1 56 48	20	....	....	......	
		M......	2 02 00	....	200*	....	......	
		C......	2 08 30	....	....	....	......	
		F......	2 25 30	....	....	....	......	
28	......	e......	18 57 18	....	....	....	......	Beginning obscured by air tremors. F occurred during daily attention to instrument.
		M......	18 58 18	....	200*	....	......	
		C......	19 08 54	....	....	....	......	
31	......	e......	18 32 30	....	....	....	......	
		M......	18 36 48	....	200*	....	......	
		C......	18 44 00	....	....	....	......	
		F......	18 50 00	....	....	....	......	

*Trace amplitude.

Kansas. **Lawrence. University of Kansas.** Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′30″ N.; long., 95° 14′58″ W. Elevation, 304.8 meters.

Instrument: Wiechert.

Instrumental constants..	V	T_0	ϵ
E	121	3.7	3.7
N	126	3.7	4.5

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Mar. 5	......	P_N....	4 22 25	....	....	....	2,370	
		S_N....	4 26 20	....	....	....	......	
		M_N....	4 28 10	....	....	....	......	
		M_E....	4 28 10	....	....	....	......	
12	......	P_N....	5 21 15	....	....	....	120?	
		S_N?...	5 21 27	....	....	....	......	
		M_N....	5 21 38	....	....	....	......	
20	......	P_N....	22 23 08	....	....	....	2,620	
		M_E....	22 31 04	....	....	....	......	

Maryland. **Cheltenham. Magnetic Observatory.** U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants..	V	T_0
E	10	31
N	10	29

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Mar. 5	......	e_N....	4 34 22	....	....	....	......	
		e_E....	4 34 25	....	....	....	......	
		M_N....	4 35 40	10	....	30	......	
		M_E....	4 37 40	10	10	....	......	
		C....	4 41 00	....	....	....	......	

Massachusetts. **Cambridge. Harvard University Seismographic Station.** J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums, undamped (mechanical registration).

Instrumental constants..	V	T_0
E	80	23
N	50	25

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Mar. 5	......	e_N....	4 36 26	....	....	....	......	
		L_E....	4 37 43	....	....	....	......	
		L_N....	4 37 58	7	....	....	......	
		F....	4 49 28	....	....	....	......	
12	......	e_N....	15 53 12	....	....	....	......	Masked by microseisms.
		L_N....	15 56 35	18	....	....	......	
		L_N....	16 01 59	....	....	....	......	
		F....	16 05 00	....	....	....	......	
20	......	e?....	22 — —	....	....	....	......	F lost in microseisms?
		L_N....	22 51 12?	18	....	....	......	
31	......	e....	17 53 16	....	....	....	......	Masked by microseisms and confused in tangled lines.
		L_E....	17 54 36	....	....	....	......	
		F?....	18 01 —	....	....	....	......	

TABLE 2.—*Instrumental reports, March, 1915*—Continued.

Missouri. **Saint Louis. St. Louis University.** Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.. V 80, T_0 7, ϵ:1 5:1

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Mar. 5	II_r..	eP?...	4 21 46				3,475	
		iS_E....	4 27 00					
		iS_N....	4 27 02					
		eL....	4 29 12					
		M_E....	4 29 58	8	9			
		M_N....	4 29 58	8		10		
		M_N....	4 30 36	9		16		
		F.....	4 44 00					

New York. **Buffalo. Canisius College.** John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

Instrumental constants: ————.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Mar. 1			4 19 00					Earth tremors, N-S.
			4 21 00					
			4 43 00					
			4 44 00					
4	I_u...	eP_E...	4 23 00				7232?	Reported in Florence, Italy.
		S_E....	4 34 00					
		L_E....	4 35 00	12	450*			
		L_N....	4 35 00			150*		
		F_E....	4 38 45					
11								Earth tremors, N-S.
12								Earth tremors, N-S.
30	I_u...	P?....	17 28 00					S indiscernible. Distant earthquake?
		L_E....	17 54 00	10	250*			

* Trace amplitude.

New York. **Fordham. Fordham University.** W. C. Repetti, S. J.

Lat., 40° 57′ 47″ N.; long., 73° 53′ 08″. W. Elevation, 23.9 meters.

Instrument: Wiechert 80 kg.

Instrumental constant.. T_0 6

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Mar. 4	I....	iL_N...	18 00 00					Because of repairs being made to the station clock, the time of each phase of this report is only approximate.
		iL_E...	18 00 30					
		M_N....	18 00 00	13		13		
		M_E....	18 00 30	13	28			
		M_E....	18 02 25	13	14			
		F_N....	18 04 45					
		F_E....	18 05 00					
5	I....	eL_N...	3 13 00					Time of each phase approximate.
		M_N....	3 15 00	6.5		2		
		M_N....	3 15 15	6.5		2		
		M_N....	3 15 50	8.2		3		
		M_E....	3 17 40	7	2			
		M_E....	3 19 15	7	2			
		F.....	3 30 00					

Panama, Canal Zone. Balboa Heights. Isthmian Canal Commission.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, ——.

Instruments: Two Bosch-Omori 25 kg.

Instrumental constants.. V 8, T_0 20

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Mar. 14	III..		.. .. ..					No record. Seismograph room in repair. Disturbance began at 12:25 p. m.
23	I....	P_E....	9 26 20				620	
		P_N....	9 26 20					
		L_E....	9 27 40					
		L_N....	9 27 40					
		M_E....	9 28 15		188			
		M_N...	9 29 35			250		
		F_N....	9 34 40					
		F_E....	9 36 00					

Vermont. **Northfield. U. S. Weather Bureau.** Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants.. E: V 20, T_0 15; N: V 25, T_0 16

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Mar. 5		e_N....	4 36 12					No well defined maximum.
		L_N....	4 37 23	11				
		F.....	5 00 00					
12		L_N....	16 01 30					No maximum.
		F.....	16 12 00					
17		L_N....	19 07 50	12				Phases doubtful.
		L_N....	19 10 15	14				
		F.....	19 30 00					

Canada. **Ottawa. Dominion Astronomical Observatory.** Earthquake Station. Otto Klotz.

Lat., 42° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			H. m. s.	Sec.	μ	μ	Km.	
Mar. 2		P_E....	21 22 46	2			1300	
		L.....	21 25 07	12-20				
		F.....	21 30 00					
5		L.....	4 36 00	20				P and S masked by microseisms.
		M_E....	4 36 08	20	12			
		M_N....	4 37 03	20		40		
		F.....	5 00 00					
12		L.....	15 56 00	24				
		F.....	16 10 00					
17		P.....	18 57 29	5			9050	
		S.....	19 07 42	6				
		L_E....	19 23 05	12				
		L.....	19 26 00	60				
		L.....	19 31 00	24 to				
			19 41 00	18				
		F.....	19 50 00					
20		e_E....	22 31 00	7				Microseisms strong.
		i.....	22 38 00	6				
		L_E....	22 41 00	9				
		F.....	22 52 00					
23		e_E....	21 38 48	4				Somewhat masked by microseisms.
		eL_E...	21 41 08	16				
		L_E....	21 46 00	20				
		L_N....	21 47 05	20				
		F.....	21 55 00					
31		e?....	17 29 26					
		L.....	17 54 04	20				
		F.....	18 02 00					

TABLE 2.—*Instrumental reports, March, 1915*—Continued.

Canada. Toronto. Dominion Meteorological Service.

Lat., 43° 40′ 01″ N.; long., 79° 22′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.59″.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Mar. 5	......	L.....	4 35 06	....	....	....	......	
		iL.....	4 35 18	....	....	....	......	
		M.....	4 35 42	....	600*	....	......	
		i.....	4 37 18	....	....	....	......	
		M.....	4 37 36	....	400*	....	......	
		F.....	4 52 00	....	....	....	......	
11	......	P.....	18 54 00	....	....	....	......	Time of P uncertain.
		S.....	19 09 06	....	....	....	......	
		SR....	19 12 12	....	....	....	......	
		L.....	19 16 18	....	....	....	......	
		iL.....	19 19 18	....	....	....	......	
		M.....	19 22 18	....	300*	....	......	
		F.....	19 55 00	....	....	....	......	Time of F uncertain.
12	......	P.....	15 25 30	....	....	....	......	Time of P uncertain.
		iS.....	15 38 12	....	....	....	......	15h 53m 54s may be the beginning of another earthquake.
		iL?....	15 53 54	....	....	....	......	
		L.....	15 58 00	....	....	....	......	
		iL	16 04 24	....	....	....	......	F doubtful, suspicion of air currents going on.
		M.....	16 10 18	....	200*	....	......	
		F.....	16 38 00	....	....	....	......	
17	......	S?.....	19 08 06	....	....	....	......	
		iL.....	19 35 54	....	100*	....	......	
		F.....	....	....	....	....	......	F lost in air currents.
20	......	P.....	22 12 30	....	....	....	......	Strong microseisms prevailed.
		S.....	22 18 54	....	....	....	......	
		L.....	22 24 30	....	....	....	......	Suspicion of air currents.
		L.....	22 35 48	....	100*	....	......	
		L.....	23 00 00	....	....	....	......	
		F.....	23 14 00	....	....	....	......	
23	......	P.....	21 30 00	....	....	....	......	Time of P uncertain.
		L.....	21 42 54	....	....	....	......	
		iL.....	21 45 06	....	....	....	......	
		M.....	21 46 48	....	500*	....	......	
		L.....	22 08 00	....	200*	....	......	
		F.....	22 12 12	....	....	....	......	

* Trace amplitude.

Canada. Victoria, B. C. Dominion Meteorological Service.

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.54″.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Mar. 5	......	iL	4 33 38	....	....	....	......	
		M.....	4 35 38	....	500*	....	......	
		F.....	4 43 08	....	....	....	......	
11	......	P.....	18 50 42	....	....	....	......	
		L.....	18 58 42	....	....	....	......	
		M.....	19 03 42	....	100*	....	......	
		F.....	19 13 42	....	....	....	......	
12	......	P.....	15 14 39	....	....	....	......	Time uncertain.
		L.....	15 27 39	....	....	....	......	
		M.....	15 29 39	....	100*	....	......	
		F.....	15 34 39	....	....	....	......	
12	......	P.....	15 48 39	....	....	....	......	May be a continuation of the preceding. All times uncertain.
		L.....	16 02 39	....	....	....	......	
		M.....	16 03 39	....	100*	....	......	
		F.....	16 22 39	....	....	....	......	
17	......	P.....	19 02 22	....	....	....	......	
		M.....	19 11 22	....	200*	....	......	
		F.....	19 25 22	....	....	....	......	
23	......	L.....	21 55 00	....	....	....	......	Phases not well defined.
		L.....	21 59 00	....	....	....	......	
		M.....	22 00 30	....	200*	....	......	
		F.....	22 05 00	....	....	....	......	

* Trace amplitude.

TABLE 3.—*Late reports.* (*Instrumental.*)

Missouri, Saint Louis. St. Louis University, Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation, 12 feet of tough clay over limestone of Mississippi System, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.. V 80, T_0 7, $\epsilon:1$ 5:1

Date.	Character.	Phase.	Time.	Period.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1915.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Feb. 25	I....	eP....	20 58 38	....	....	....	8,000	S probably mersed in local disturbance.
		eS?....	21 08 00	....	....	....	......	
		M_E....	20 59 24	5	8	....	......	
		M_N....	20 59 54	7	....	9	......	Microseisms were of frequent occurrence throughout the month.
		F.....	21 12 00	....	....	....	......	

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

American climatological and clinical association.
Transactions, 1914, v. 33. Philadelphia. 1914. xxviii, 312 p. & app. plates. 24½ cm. [Appendix 1: "Atmospheric air in relation to tuberculosis," by Guy Hinsdale; originally published by the Smithsonian institution.]

Carpenter, Ford A.
Two lectures on climatic conditions [in California]. 1. Weather conditions one hundred thousand feet above the earth. 2. The dollar and cents value of California meteorology. (*In* University of California chronicle, Berkeley, Jan., 1915, vol. 17, no. 1, p. 68–90.)

Egypt. Survey department.
Meteorological report for the year 1912. Cairo. 1914. xxii, 237, xii p. 32 cm. [Climatological normals for Abbassia (temperature, pressure, relative humidity, and vapour pressure), by Myer M. Orenstein, p. xvii–xxii.]

Geneva. Observatoire.
Observations météorologiques faites aux fortifications de Saint-Maurice pendant l'année 1913. Genève. 1914. 56 p. 22½ cm. (Extrait des Archives des sciences physiques et naturelles, juin, août et octobre 1914.)
Résumé météorologique de l'année 1913 pour Genève et le Grand Saint-Bernard. Genève. 1914. 104 p. 22 cm. (Tiré des Archives des sciences de la Bibliothèque universelle, avril et mai 1914.)

Great Britain. Meteorological office.
Monthly normals of temperature, rainfall, and sunshine. A revised edition of the quinquennial appendix to the Weekly weather report, giving averages of temperature and rainfall for the periods of 35 years and 40 years and of sunshine for the period of 30 years ended 1910, with maps. London. 1915. 241–264 p. 16 p. of maps. 31½ cm. (British meteorological and magnetic year book, 1913, pt. 1, app. iv.)

Hellmann, G[ustav].
Regenkarten der Provinzen Hessen-Nassau und Rheinland, sowie von Hohenzollern und Oberhessen. 2. verm. Aufl. Berlin. 1914. 43 p. 2 pl. 27 cm. (Veröffentlichungen des Königlich preussischen meteorologischen Instituts, Nr. 280.)

Hildebrandsson, H[ugo] Hildebrand.
Quelques recherches sur les centres d'action de l'atmosphère. V (fin). Uppsala & Stockholm. 1914. 16 p. 13 pl. 31½ cm. (Kungl. Svenska vetenskapsakademiens handlingar, band 51, no. 8.)

Hinsdale, Guy.
The climate of California. From the course on climatology in the Medico-chirurgical college, Philadelphia, 1915. 8 p. 23½ cm. (Reprinted from the Bulletin of the Medico-chirurgical college of Philadelphia, February, 1915.)

Huntington, Ellsworth.
The climatic factor as illustrated in arid America. With contributions by Charles Schuchert, Andrew E. Douglass, and Charles J. Kullmer. Washington. 1914. vi, 341 p. plates. maps. 30 cm. (Carnegie institution of Washington. Publication no. 192.) [See page 136, above.]

International council for the study of the sea.
Bulletin hydrographique pour l'année juillet 1912–juin 1913. [German and English text.] Copenhague. [1914.] v. p. plates. 32½ cm.

Martin, Edward A.
Dew-ponds; history, observation and experiment. London. n. d. 208 p. plates. 19½ cm.

Mysore. Meteorological department.
Meteorology in Mysore for 1913, being the results of observations at Bangalore, Mysore, Hassan, and Chitaldrug. 21st annual report. Bangalore. 1915. xi, 56 p. 2 pl. 31½ cm.

Odell, L. M.
Weather chart exercises (British Isles and west of Europe). London. n. d. 32 p. 24½ cm.

Prussia. K. Meteorologisches Institut.
Ergebnisse der Beobachtungen an den Stationen II. und III. Ordnung im Jahre 1912, von G. Lüdeling. Berlin. 1914. xvi, 182 p. map. 34 cm. (Veröffentlichungen, Nr. 281.)
Ergebnisse der Gewitter-Beobachtungen in den Jahren 1911 und 1912, von Th. Arendt. Berlin. 1915. xlii, 40 p. 34 cm. (Veröffentlichungen, Nr. 282.)
Ergebnisse der meteorologischen Beobachtungen in Potsdam im Jahre 1913, von R. Süring. Berlin. 1914. xxxiv, 98 p. 34 cm. (Veröffentlichungen, Nr. 279.)

Richard, Jules.
Instruments de précision enregistreurs. Météorologie. Paris. 1914. v. p. 27 cm.

Smith, J. Warren, & Patton, C. A.
Ohio weather for 1913. [Wooster, O. 1914.] 331–406 p. 23 cm. (Ohio agricultural experiment station. Bulletin 277.) [Contains, in addition to the usual tables, "a series of diagrammatic maps, showing at a glance the comparative weather conditions for the different sections of the State."]

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

American climatological and clinical association. Transactions. Philadelphia. v. 30. 1914.
Stupart, R[obert] F[rederic]. The climate of south-western Alberta. p. 9–15.
Nichols, Estes. Housing and its relation to climate and health. p. 16–26.

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SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

By P. C. DAY, Climatologist and Chief of Division.

As affecting crop conditions, March was on the whole unfavorable over the districts east of the Mississippi. In the winter grain belt cold weather delayed growth, and lack of surface moisture, especially over the more eastern districts, doubtless materially lessened the vitality of the plants already injured by the frequent freezing and thawing owing to lack of snow covering during the winter. In the districts west of the Mississippi the snow covering was more satisfactory and the moisture therefrom entered the ground slowly, and the crop at the end of the month was not seriously in need of more moisture, while in the far West it was reported as being in good condition.

In the trucking districts of the far South cold weather seriously injured the early crops, while farther north it delayed planting and germination.

Pressure.—The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing direction of the winds, are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

For the month as a whole the barometric pressure was low over the New England and Middle and South Atlantic States, including all of Florida, the eastern portion of Tennessee, and the Canadian Provinces east of Lake Huron. The most marked negative departures occurred in the New England States and the Canadian Provinces to the northeastward, where they were unusually large. Over all other portions of the country the means for the month were above the normal, with the greatest positive departures appearing in eastern Montana, the Dakotas, Nebraska, and western portions of Kansas and Minnesota, and that portion of Canada just north of those States.

During the first few days of the month a marked high pressure area obtained throughout the Central Valleys, while elsewhere the pressure was near the normal. These conditions were followed by a low area of considerable magnitude which covered the larger part of the country east of the Rocky Mountains, which in turn was followed by a rather marked high area extending from Canada to the Gulf, which conditions continued until near the middle of the month, during which time the weather was generally clear and comparatively cool.

From the middle until the end of the month moderately low and relatively high pressure areas followed one another across the country in rather rapid succession, but the high areas largely predominated, resulting in much fair and rather cold weather, with comparatively little rain in most sections.

The distribution of the highs and lows was favorable for general northwesterly winds in the Mississippi Valley and to the eastward, and northerly in Texas, Oklahoma, the western portions of Kansas, Nebraska, and in the Dakotas. Elsewhere variable winds prevailed.

Temperature.—Not since extensive official meteorological records began, more than 40 years ago, has the weather for March, over the southeastern portions of the country, been so continuously cold as during the month just ended. In some of the States of this section the average temperature for each day of the month, with one or two exceptions, was below the normal. The small variations in temperature from day to day were also unusual, the daily changes showing no greater variations than would be expected in a summer month, a condition most unusual for March, notable for its changeable weather.

These remarkably continuous low temperature conditions were due to the persistent low pressure that obtained in the Atlantic Coast States and over the ocean to the eastward and northeastward, in conjunction with high barometric readings over the interior of the country. This pressure distribution resulted in a pronounced prevalence of northwesterly winds over the country from the Plains region eastward to the Atlantic, causing an influx over those districts of cold air from northern districts. However, over the extreme northern section and to the westward of the Rocky Mountains the temperature was more seasonable and somewhat above normal.

Save for moderately low temperatures in the South, March opened with fair and pleasant weather in nearly all districts. These conditions were maintained until the 3d, when lower temperatures overspread the northern districts and stormy weather, with rain or snow, developed over the Rocky Mountain districts and the Southwest. Cloudy weather, with rather widespread precipitation, prevailed for several days during the passage eastward of the storm area, but by the end of the first week high pressure had again become the dominant feature of the weather and low temperatures for the season of the year prevailed in all districts save in the far West.

Temperature changes were not marked during the next few days. There was a tendency to warm up in nearly all districts; the weather continued abnormally cool, however, in the Gulf States where heavy frosts occurred, and in the Missouri Valley where the early morning temperatures were near or below zero.

At the close of the second week of the month there was a change to more seasonable temperatures, and warmer weather set in over the Northwest and far West; but unusually steady cold still continued in the more southerly districts. By the middle of the month day temperatures had become unusually high in the Pacific Coast States; but high pressure with attendant cold northerly winds still persisted in the South, while along the northern border, the prevailing winds being southerly, more seasonable temperatures obtained.

The period from the 14th to the 24th was remarkably cold over the extreme southern portions of the country, the average for the period being nearly 15° below the normal on the Texas coast, while in extreme southern Florida it was 10° or more below normal.

During the same period the average temperatures over the Pacific Coast States were considerably above normal, and from about the 21st to 23d the day temperatures were unusually high.

With only slight variations from day to day, the weather during the last week of the month continued cold for the season over the Southern States, although the negative departures were somewhat less than during the preceding period. In the northern districts the last week of the month was cold throughout, while in portions of the far West the week was moderately warm.

At the close of the month cold weather still prevailed in the Northwest, with temperatures of 20° or more below the freezing point in the Dakotas, while almost winter conditions prevailed in portions of the Gulf States.

Precipitation.—The storm that developed over the far Southwest near the first of the month moved slowly eastward, and by the morning of the 4th light rains and snows had fallen over much of the Rocky Mountain and Great Plains regions, and some heavy rains had occurred in eastern Texas and portions of the lower Mississippi Valley. During the following few days the storm center moved northeastward to the Great Lakes, and the precipitation area gradually extended over all districts from the Mississippi Valley eastward to the Atlantic coast. Heavy rains occurred in the east Gulf and South Atlantic States and portions of the Ohio Valley, and heavy snows in the lower Missouri and portions of the upper Mississippi Valleys, and lighter falls were general in the Lake region and Appalachian Mountain districts from Virginia northward. With the passage eastward of the above-mentioned storm, fair weather prevailed in most districts until about the end of the first decade, when light rains and snows occurred in the Southwest and extended eastward over much of Texas and Oklahoma.

The first half of the second decade was unusually free from precipitation in all parts of the country save the extreme Northwest, where some heavy rains occurred near the coast. About the 15th, however, unsettled weather developed in the districts to the eastward of the Mississippi, and light rains were fairly general during the following day over the east Gulf and South Atlantic States, with light local snows in parts of the Appalachian Mountains and to the westward as far as the Mississippi Valley.

Fair weather was again dominant during the latter part of the second decade, except for some local rains or snows in the central and eastern districts and at a few points in the Rocky Mountain region. Somewhat unsettled weather, with local rains and snows, mostly light, continued for several days at the beginning of the third decade. In a few localities heavy falls of snow occurred, notably in portions of the mountainous districts of Kentucky where the fall was as much as 1 foot, and in portions of South Dakota where heavy drifts caused some delay to traffic.

The latter part of the month was notably free from any considerable precipitation except near the end, when a storm moved into the Pacific coast States, with some heavy rains in northern California, and light snow as it passed eastward over the mountains. At the end of the month this storm had moved rapidly to the South Atlantic coast, and local rains and snows had occurred over considerable areas of the central and southern portions of the country. The falls were mostly light, however, except in portions of the Gulf States, where substantial rains occurred.

In portions of New England and other northeastern States the monthly precipitation was the least ever known for March, and in some cases, as at Boston with a record extending back nearly 100 years, the amount recorded during the month just closed was the least for any month of the entire period. Precipitation was likewise deficient throughout all other portions of the country to the eastward of the Mississippi and generally to westward of the Rocky Mountains. The only portion of the country in which an appreciable excess of precipitation occurred was the middle Plains region, where heavy snow early in the month was sufficient to give monthly totals above the normal.

The most important fall of snow for the month occurred about the 5th and 6th and covered the northern Plains region, the heaviest falls occurring in central Nebraska and the adjoining portions of Kansas and South Dakota, and lighter falls thence northeastward to the upper Lakes. This body of snow remained largely unmelted for several weeks and at the end of the month portions of it were still unmelted, especially in Nebraska and South Dakota. After the end of the first decade there was, as a rule, little additional snowfall and the covered area gradually decreased, and at the close of the month only small areas in the more northern districts remained snow covered. But little snow occurred during the month in the northern mountain districts and as the fall during the preceding months had been largely deficient, the outlook for a good water supply for the coming irrigation season is accordingly poor. In the middle mountain districts the fall for the winter was more nearly normal, while in California and portions of the southern mountain districts there was an abundance of snow during the winter and the outlook at the close of March was favorable for a plentiful supply of water until late in the summer.

Average accumulated departures for March, 1915.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	Ins.	Ins.	Ins.	0-10		P. ct.	
New England	32.4	−0.5	+ 8.2	0.21	−3.60	−1.20	3.8	−1.9	62	−13
Middle Atlantic	37.0	−3.0	+ 4.6	1.16	−2.50	−0.10	4.1	−1.6	62	−10
South Atlantic	46.5	−7.3	− 4.6	2.14	−2.20	−2.20	4.9	0.0	66	− 9
Florida Peninsula	62.1	−8.1	−10.2	1.72	−0.60	+3.00	6.1	+2.3	72	− 5
East Gulf	49.0	−8.3	− 9.3	3.07	−2.80	−1.50	5.0	0.0	67	− 6
West Gulf	48.2	−9.8	− 6.8	2.28	−0.80	−1.40	6.2	+1.1	72	0
Ohio Valley and Tennessee	37.4	−6.7	− 2.5	1.78	−2.60	−3.50	6.0	0.0	69	− 2
Lower Lakes	29.8	−3.1	+ 2.2	1.00	−1.60	−1.40	5.2	−1.4	74	− 2
Upper Lakes	28.5	+0.9	+ 8.4	0.78	−1.50	−1.30	5.4	−0.6	75	− 4
North Dakota	23.2	+2.4	+16.0	0.28	−0.70	−1.10	4.5	−1.1	77	− 1
Upper Mississippi Valley	33.0	−3.0	+ 4.9	0.79	−1.60	−0.40	5.9	+0.2	76	+ 3
Missouri Valley	28.8	−7.2	+ 1.5	1.51	−0.40	−1.80	7.2	+1.5	83	+11
Northern slope	30.3	−0.6	+ 5.8	0.96	−0.10	−0.70	5.9	+0.5	75	+ 8
Middle slope	34.0	−8.5	− 0.7	1.44	0.00	+1.50	6.9	+2.3	75	+15
Southern slope	44.0	−9.2	− 6.5	1.18	+0.30	+0.70	6.4	+2.0	67	+12
Southern Plateau	48.2	−2.8	− 7.9	0.52	0.00	+1.00	3.5	−0.2	50	+14
Middle Plateau	43.3	−2.3	− 1.0	0.60	−0.70	−0.50	5.0	0.0	50	− 6
Northern Plateau	45.9	+5.6	+11.0	1.38	−0.20	−1.10	5.7	−0.1	58	− 8
North Pacific	49.8	+5.6	+10.3	3.24	−1.70	−4.70	6.3	−0.3	77	+ 2
Middle Pacific	54.9	+3.6	+ 4.2	2.12	−2.00	+4.50	5.3	−0.1	71	− 3
South Pacific	59.4	+4.2	+ 6.9	0.60	−2.00	+3.30	4.5	−2.6	70	− 1

Maximum wind velocities, March, 1915.

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mi. hr.				Mi. hr.	
Block Island, R. I	3	54	nw.	North Head, Wash.	17	70	s.
Do	26	60	nw.	Do	29	52	s.
Do	27	58	nw.	Do	31	52	se.
Do	30	71	nw.	Point Reyes Light, Cal	1	78	nw.
Buffalo, N. Y	2	50	nw.	Do	2	57	nw.
Fort Worth, Tex.	30	50	nw.	Do	3	61	nw.
Mount Tamalpais, Cal	1	57	nw.	Do	4	60	nw.
Do	4	64	nw.	Do	5	56	nw.
Do	27	50	se.	Do	6	57	nw.
Do	28	54	sw.	Do	26	60	s.
New York, N. Y	2	54	nw.	Do	27	67	s.
Do	3	62	nw.	Do	28	50	s.
Do	12	50	nw.	Providence, R. I	26	59	nw.
Do	21	54	nw.	Sandy Hook, N. J	3	52	nw.
Do	26	60	nw.	Do	30	56	w.
Do	30	60	nw.	Tatoosh Island, Wash	14	56	s.
Norfolk, Va	22	52	w.	Do	17	58	s.
North Head, Wash.	13	50	se.	Do	20	56	e.
Do	14	62	se.				

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data, as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Summary of temperature and precipitation, by sections, March, 1915.

Section.	Temperature (° F.).								Precipitation (in inches and hundredths).					
			Monthly extremes.								Greatest monthly.		Least monthly.	
	Section average.	Departure from the normal.	Station.	Highest.	Date.	Station.	Lowest.	Date.	Section average.	Departure from the normal.	Station.	Amount.	Station.	Amount.
Alabama	47.3	− 9.9	4 stations	80	26	Hamilton	20	23†	3.21	−2.56	Bay Minette	5.85	Ozark	1.00
Arizona	50.3	− 2.3	Parker	97	16†	2 stations	− 9	1†	0.81	−0.15	Lakeside	2.31	2 stations	0.00
Arkansas	42.5	−10.6	Dardanelle	73	28	Dodd City	14	1	3.54	−1.11	Newport	5.70	Corning	1.73
California	53.1	+ 1.3	2 stations	94	16†	Tamarack	−11	5	2.33	−2.41	Delta	13.13	2 stations	0.00
Colorado	30.9	− 4.3	Lamar	76	23	Dillon	−33	20	0.93	−0.24	Long's Peak	4.06	Gunnison	0.00
Florida	57.0	− 9.1	Hypoluxo	90	31	Mount Pleasant	25	23	2.60	−0.40	Newport	7.15	Rockwell	1.05
Georgia	47.7	− 9.4	Quitman	83	26	3 stations	20	23†	2.60	−2.39	Blakely	3.93	Allapaha	1.31
Hawaii [February]	66.3	......	Waiawa	87	25	Volcano House	40	18	5.55	......	Honomanu Valley	29.00	2 stations	0.00
Idaho	41.1	+ 4.4	3 stations	78	22†	Pierson	−13	8	1.06	−0.59	Musselshell	3.28	Glenns Ferry	0.12
Illinois	35.5	− 4.2	Golconda	65	25	Lanark	4	9	0.84	−2.19	Antioch	1.75	Dakota	0.11
Indiana	35.3	− 6.5	3 stations	61	14†	2 stations	9	1†	1.15	−2.78	Cambridge City	2.02	Collegeville	0.10
Iowa	29.3	− 4.0	Burlington	61	24	Inwood	− 5	8	0.96	−0.81	Monroe	2.12	Waverly	0.17
Kansas	33.0	− 9.9	2 stations	72	24	Hill City	− 7	9	1.75	+0.34	Chanute	4.05	Santa Fe	0.08
Kentucky	37.8	− 8.5	3 stations	65	25	Williamsburg	11	17	2.11	−2.78	Alpha	3.70	Beaver Dam	1.07
Louisiana	50.4	−10.2	2 stations	84	26†	Liberty Hill	20	22	2.82	−1.59	Lake Charles	5.14	Avoca Island	1.44
Maryland and Delaware.	36.9	− 5.8	Great Falls, Md	64	25	Deer Park, Md	3	13	1.16	−2.42	Deer Park, Md	2.16	Delaware City, Del	0.43
Michigan	28.4	− 0.8	2 stations	57	14†	Iron River	−15	3	0.74	−1.36	Chatham	2.00	Sault Ste. Marie	0.09
Minnesota	25.7	− 0.3	2 stations	54	22†	Hallock	−20	2	0.55	−0.60	Tracy	2.05	Red Lake Falls	0.02
Mississippi	47.5	−10.6	2 stations	79	30	Fayette	21	22	3.08	−2.78	University	4.20	McNeill	1.92
Missouri	36.4	− 8.1	Jefferson City	70	24	Clinton	6	6	1.50	−1.74	Lockwood	3.67	Crocker	0.35
Montana	32.5	+ 2.9	Superior	74	24	Bowen	−18	7	0.74	−0.17	Garneill	4.60	Mildred	0.00
Nebraska	26.2	− 8.8	Grant	67	23	3 stations	−13	8†	1.99	+0.85	Ainsworth	3.87	Dumas	0.95
Nevada	42.8	+ 3.0	Logan	89	31	Gold Creek	− 5	6	0.45	−0.64	Lida	2.67	2 stations	T.
New England	30.7	− 0.2	Cornish, Me	62	24	Greenville, Me	−10	27	0.21	−3.69	Van Buren, Me	1.56	Rockport, Mass	0.00
New Jersey	36.1	− 1.9	Long Branch	63	25	Culvers Lake	6	4	1.13	−2.87	Long Branch	1.65	Sandy Hook	0.58
New Mexico	38.0	− 5.3	Artesia	86	24	Rociada	−11	21	1.34	−0.40	Anchor Mine	3.98	Bluewater	T.
New York	29.2	− 3.3	2 stations	62	25	Nehasane	−15	4	0.64	−2.48	Lake Placid Club	2.48	4 stations	0.00
North Carolina	42.0	− 8.7	Rockingham	78	27	Banners Elk	10	17	2.61	−1.87	Highlands	5.62	Manteo	0.47
North Dakota	23.3	+ 1.0	Hansboro	63	10	Walhalla	−23	2	0.22	−0.65	Wahpeton	1.37	6 stations	0.00
Ohio	33.2	− 6.1	Ironton	61	25	Medina	3	29	1.44	−2.12	Ironton	2.59	2 stations	0.65
Oklahoma	39.8	−12.5	3 stations	86	23†	Hurley	10	6	2.13	+0.24	Idabel	10.60	Erick	0.08
Oregon	46.9	+ 5.1	Cazadero	86	22	Yonna	5	25	2.24	−1.27	Glenora	7.15	Big Basin	0.17
Pennsylvania	32.9	− 5.0	Lancaster	62	25	West Bingham	− 4	9	1.28	−2.41	Punxsutawney	2.80	George School	0.57
Porto Rico	75.3	+ 1.5	Guanica Centrale	100	29†	Cayey	47	12	2.24	−1.54	Rio Grande	13.26	2 stations	0.00
South Carolina	46.3	− 8.3	Walterboro	81	26	Liberty	22	23	2.66	−1.26	Winnsboro	4.10	2 stations	1.45
South Dakota	22.1	− 8.4	Daviston	62	22	2 stations	−16	8†	1.11	+0.04	Milbank	3.06	Castlewood	0.07
Tennessee	40.5	− 9.1	2 stations	69	25	Mountain City	12	18	2.78	−2.46	Lookout Mountain	4.27	Mountain City	1.10
Texas	49.1	−10.3	Fort McIntosh	92	30	2 stations	15	8†	1.83	−0.29	Matagorda	8.03	Encinal	0.11
Utah	39.9	+ 1.0	St. George	81	26	East Portal	−14	11	0.75	−0.79	Utah Exp. Station	2.08	2 stations	0.00
Virginia	38.5	− 6.7	3 stations	66	25	Burkes Garden	11	13	1.26	−2.60	Rocky Mount	2.65	Warsaw	0.32
Washington	46.6	+ 5.5	4 stations	83	20†	Sweat Creek	8	4	2.41	−0.54	Quiniault	15.75	Republic	0.02
West Virginia	34.4	− 9.1	Hinton	63	25	Bayard	7	4†	1.61	−2.43	Pickens	4.32	Cuba	0.53
Wisconsin	27.5	− 1.4	Watertown	58	24	Vudesare (2)	−22	3	0.59	−1.19	New Richmond	1.70	Downing	T.
Wyoming	28.8	− 1.1	Eaton's Ranch	72	22	Lake Yellowstone	−24	4	1.07	−0.05	Pinebluff	3.10	Border	0.02

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th meridian time, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes*, the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred, the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading and (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading, and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduces to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2, of the annual report just mentioned. The correction t_0-t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is. sufficiently extensive to justify its preparation.

TABLE I.—*Climatological data for United States Weather Bureau stations, March, 1915.*

Districts and stations.	Elevation of instruments: Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Pressure in inches: Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air, in degrees Fahrenheit: Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches: Total.	Departure from normal.	Days with 0.01 or more.	Wind: Total movement, miles.	Prevailing direction.	Maximum velocity: Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
New England.							**32.4**	**−0.5**										**62**	**0.21**	**−3.6**										**3.8**		
Eastport	76	67	85	29.56	29.65	−0.28	29.9	+1.0	53	25	36	10	27	23	26	26	21	69	0.57	−3.7	8	10,036	nw.	40	w.	27	5	17	9	6.1	4.8	
Greenville	1,070	6		28.52	29.71		23.2		48	25	32	−10	27	15	30				0.24		4										2.1	3.0
Portland, Me.	103	82	117	29.64	29.76	−.20	32.2	+0.2	54	25	41	12	3	24	28	26	16	52	0.09	−3.7	3	8,217	nw.	36	nw.	26	18	7	6	3.9	0.8	
Concord	288	70	79	29.46	29.78	−.22	31.7	+0.2	55	25	41	10	3	23	28				T.	−3.4	0	6,123	nw.	31	nw.	27	20	9	2	2.1	T.	
Burlington	404	11	48	29.40	29.86	−.14	25.6	−1.7	48	25	33	5	3	18	27				0.22	−1.6	5	7,255	n.	36	nw.	26	10	12	9	5.0	3.2	
Northfield	876	12	60	28.86	29.84	−.16	24.9	−1.3	49	25	34	5	3	16	28	22	17	73	0.25	−2.5	5	6,124	n.	32	nw.	27	11	12	8	5.2	1.6	T.
Boston	125	115	188	29.64	29.78	−.19	35.8	+0.8	60	25	44	13	3	27	31	30	21	58	T.	−4.1	0	9,237	nw.	37	w.	26	20	8	3	2.8	T.	
Nantucket	12	14	90	29.75	29.76	−.22	35.0	−1.8	52	25	41	17	3	29	22	30	25	68	0.25	−3.7	5	12,088	nw.	43	nw.	26	17	10	4	4.3	1.0	
Block Island	26	11	46	29.76	29.79	−.19	34.8	−1.1	51	25	41	18	3	29	22	31	26	71	0.33	−4.0	3	16,590	nw.	71	nw.	30	22	4	5	3.1	2.2	T.
Narragansett Pier		9					34.1	−0.9	52	25	44	9	4	25	36				0.34		6		sw.				25	4	2		2.2	T.
Providence	160	215	251	29.61	29.79	−.19	34.3	−1.4	56	25	43	14	3	26	29	29	20	56	0.07	−4.6	2	13,162	nw.	59	nw.	26	22	4	5	3.0	0.1	
Hartford	159	122	140	29.65	29.83	−.16	34.8	−0.2	58	25	43	14	3	26	29	29	21	60	0.29	−4.0	3	6,734	nw.	32	w.	3	17	9	5	3.5	1.0	
New Haven	106	117	155	29.72	29.84	−.15	36.0	+0.6	58	25	45	16	3	27	30	28	17	49	0.25	−4.2	5	8,467	nw.	35	nw.	26	20	8	3	2.9	0.7	
Middle Atlantic States.							**37.0**	**−3.0**										**62**	**1.16**	**−2.5**										**4.1**		
Albany	97	102	115	29.77	29.88	−.13	32.4	+0.3	54	25	40	13	4	24	23	27	22	69	0.60	−2.6	4	6,882	nw.	32	w	26	21	7	3	2.7	0.8	
Binghamton	871	10	69	28.96	29.91	−.11	29.8	−2.2	51	25	37	12	4	22	26				0.90	−1.7	10	4,541	nw.	24	nw.	26	13	4	14	5.4	8.3	T.
New York	314	414	454	29.52	29.86	−.14	36.4	−1.1	55	25	44	18	3	28	24	29	20	53	1.14	−3.0	3	16,661	nw.	62	nw.	3	19	7	5	3.8	7.7	
Harrisburg	374	94	104	29.54	29.95	−.08	36.0	−1.8	54	25	43	19	4	29	23	30	21	58	1.86	−1.3	6	6,841	nw.	28	nw.	30	13	11	7	4.3	13.2	
Philadelphia	117	123	190	29.78	29.91	−.11	38.7	−1.3	58	25	46	22	4	31	22	33	26	62	1.00	−2.4	4	9,900	nw.	36	nw.	30	19	9	3	3.1	8.2	
Reading	325	81	98	29.56	29.92		36.2		58	25	44	19	30	28	24	30	21	56	1.42	−2.1	8	7,037	nw.	30	nw.	3	13	11	7	4.4	15.3	
Scranton	805	111	119	29.04	29.92	−.10	31.6	−3.3	53	25	39	13	30	24	24	28	24	74	1.21	−1.9	4	6,400	nw.	32	sw.	26	11	14	6	4.5	6.9	
Atlantic City	52	37	48	29.84	29.90	−.12	37.1	−1.7	54	25	45	20	4	29	24	31	24	61	1.29	−2.4	3	6,764	nw.	26	nw.	30	21	5	5	3.4	0.3	
Cape May	18	13	49	29.91	29.93	−.08	38.8	−2.0	57	25	45	24	4	32	20				0.94	−2.8	4	8,479	nw.	36	e.	6	15	12	4	3.5	0.5	
Sandy Hook	22	10	57	29.85	29.87		36.6		57	25	43	22	4	30	19	33	30	82	0.58		2	14,468	nw.	56	w.	30	14	13	4	4.1	5.7	
Trenton	190	150	183	29.67	29.88		36.0		57	25	44	20	4	28	22	30	21	58	1.37	−2.7	4	10,124	nw.	40	nw.	30	17	9	5	3.5	8.4	
Baltimore	123	100	113	29.82	29.95	−.08	39.4	−2.5	60	25	47	23	4	32	22	33	24	57	1.06	−2.8	4	6,305	nw.	31	nw.	31	17	9	5	4.0	5.0	
Washington	112	62	85	29.82	29.95	−.09	38.8	−3.4	62	25	47	23	30	30	30	32	24	57	1.07	−2.8	5	7,031	nw.	31	nw.	21	12	12	7	4.6	2.5	
Lynchburg	681	153	188	29.20	29.96	−.09	41.2	−4.2	66	25	51	26	4	32	37	35	28	63	1.14	−2.7	5	6,199	nw.	29	n.	8	12	12	7	5.1	3.1	
Norfolk	91	170	205	29.84	29.94	−.09	42.4	−5.3	62	25	50	28	9	35	24	35	27	60	1.14	−3.1	7	9,810	nw.	52	w.	22	11	10	10	4.7	T.	
Richmond	144	11	52	29.81	29.97	−.07	40.6	−6.3	63	25	50	26	28	32	30	34	24	56	1.10	−2.6	7	6,229	nw.	28	sw.	25	16	7	8	4.2	0.3	
Wytheville	2,293	40	47	27.55	30.00	−.05	34.4	−7.9	55	25	42	20	13	26	35	29	23	68	1.90	−2.6	7	5,070	w.	24	w.	25	19	3	9	3.8	13.7	
South Atlantic States.							**46.5**	**−7.3**										**66**	**2.14**	**−2.2**										**4.9**		
Asheville	2,255	70	84	27.59	30.02	−.04	36.8	−8.1	63	25	45	20	22	28	34	31	24	66	2.00	−3.1	9	6,327	nw.	29	n.	17	14	7	10	4.9	11.9	T.
Charlotte	773	68	76	29.13	29.98	−.07	43.1	−7.7	68	26	52	27	18	34	27	36	28	61	3.44	−1.1	11	5,314	sw.	30	sw.	22	9	13	9	5.4	6.7	
Hatteras	11	12	50	29.92	29.93	−.11	45.2	−6.2	64	26	51	33	30	39	24	40	34	70	1.11	−4.4	10	11,647	ne.	47	w.	22	11	10	10	5.1	T.	
Manteo	12	4	46				42.2		66	28	51	25	15	33					0.43	−4.6	4		n.				17	8	6			
Raleigh	376	103	110	29.55	29.97	−.08	42.7	−7.7	65	25	52	28	18	34	34	35	27	58	2.63	−1.6	12	6,158	n.	30	w.	22	13	12	6	4.6	4.2	T.
Wilmington	78	81	91	29.88	29.97	−.08	46.4	−7.3	75	26	56	31	18	36	26	39	33	60	2.18	−1.4	7	5,739	w.	34	w.	22	12	12	7	4.2	1.0	
Charleston	48	11	92	29.93	29.98	−.08	49.6	−7.6	74	26	58	34	23	42	25	43	37	69	2.83	−0.9	6	8,236	nw.	35	ne.	4	13	11	7	4.7		
Columbia, S. C.	351	41	57	29.60	30.00	−.06	46.6	−7.4	76	26	57	30	2	36	29	38	29	58	2.33	−1.4	10	5,650	nw.	31	sw.	7	15	3	13	5.1	0.7	
Augusta	180	89	97	29.80	30.00	−.06	47.3	−8.6	76	26	58	29	23	37	33	41	35	70	2.08	−2.8	7	5,303	nw.	30	w.	16	15	5	11	4.8	0.1	
Savannah	65	150	194	29.93	30.00	−.06	51.8	−6.5	77	26	61	35	23	43	29	44	38	67	2.06	−1.6	6	10,235	nw.	44	nw.	16	12	9	10	4.9		
Jacksonville	43	96	129	29.96	30.01	−.05	55.8	−6.1	77	5	65	38	9	47	28	49	45	74	2.47	−1.0	7		w.				11	10	10	5.2		
Florida Peninsula.							**62.1**	**−8.1**										**72**	**1.72**	**−0.6**										**6.1**		
Key West	22	10	64	29.99	30.01	−.04	65.6	−7.2	79	4	71	53	18	61	16	59	56	73	2.25	+0.8	7	7,526	n.	32	n.	21	8	11	12	5.9		
Miami	25	71	79	29.98	30.01		63.0	−9.0	82	31	71	43	9	56	23	56	52	71	1.57	−1.2	6	6,068	nw.	26	nw.	17	7	8	16	6.6		
Sand Key	23	39	72	29.96	29.99	−.03	66.2		76	4	70	54	22	63	13	60	57	73	2.20		8	10,779	n.	42	n.	21	9	11	11	5.6		
Tampa	35	79	96	29.99	30.03	−.04	57.8	−8.1	76	31	66	40	8	50	26	51	46	71	1.35	−1.5	5	5,354	w.	25	nw.	17	7	10	14	6.2		
Titusville	44	6																														
East Gulf States.							**49.0**	**−8.3**										**67**	**3.07**	**−2.8**										**5.0**		
Atlanta	1,174	190	216	28.76	30.02	−.04	43.6	−8.8	67	26	52	25	22	35	25	38	32	67	2.01	−3.8	11	9,679	nw.	42	nw.	16	12	5	14	5.4	0.2	
Macon	370	78	87	29.61	30.01	−.05	47.9	−6.9	77	26	59	26	23	37	35	41	34	65	2.40	−3.1	8	5,268	nw.	26	w.	7	15	8	8	4.4		
Thomasville	273	8	57	29.72	30.02	−.04	52.2	−8.0	79	26	64	27	23	40	38	44	40	73	3.17	−1.9	7	4,351	nw.	21	nw.	16	13	7	11	4.9		
Pensacola	56	140	182	29.99	30.05	−.01	53.1	−8.0	71	27	60	32	22	46	21	46	40	67	3.87	−1.5	7	9,609	nw.	49	se.	4	10	13	8	5.3		
Anniston	741	9	57	29.25	30.06	.00	44.4	−8.1	69	26	55	25	24	33	32				3.03	−2.8	11	5,064	nw.	34	se.	4	13	10	8	4.7	3.0	
Birmingham	700	11	48	29.29	30.08	+.02	45.4	−9.8	71	26	56	27	22	35	28	38	30	62	3.68	−2.1	12	5,230	nw.	35	se.	4	12	8	11	5.0	2.8	
Mobile	57	125	161	30.00	30.05	−.01	52.4	−6.7	72	26	60	32	22	44	26	46	40	68	3.46	−3.7	5	7,775	nw.	38	nw.	30	11	10	10	4.9		
Montgomery	223	100	112	29.80	30.06	.00	49.8	−9.0	75	26	59	30	22	41	30	42	33	59	4.24	−2.1	6	5,548	nw.	26	se.	4	15	8	8	4.5		
Meridian	375	85	93	29.66	30.07	+.02	47.3	−9.0	72	26	57	27	23	37	32	42	37	73	2.50	−3.1	8	4,662	nw.	23	w.	21	12	6	13	5.3	4.0	
Vicksburg	247	65	74	29.82	30.11	+.07	48.0	−10.2	71	25	56	30	22	40	28	41	34	65	3.05	−3.2	7	5,306	nw.	36	nw.	30	9	9	13	5.6		
New Orleans	51	90	121	30.00	30.06	+.02	55.0	−7.0	78	30	63	35	22	47	26	49	44	73	2.31	−3.0	9	6,302	nw.	28	se.	4	9	15	7	4.7		
West Gulf States.							**48.2**	**−9.8**										**72**	**2.28**	**−0.8**										**6.2**		
Shreveport	249	77	93	29.83	30.11	+.09	47.2	−11.0	74	25	56	29	22	39	32	41	36	60	1.92	−2.6	9	5,922	n.	29	w.	4	9	4	18	6.2		
Bentonville	1,303	11	44	28.69	30.10	+.09	36.8	−10.5	62	14	44	21	21	29	31				3.83	0.0	11	4,175	nw.	22	s.	24	5	6	20	7.8	3.6	
Fort Smith	457	79	94	29.61	30.10	+.09	42.0	−9.3	65	24	49	25	21	35	33	36	31	69	3.92	+0.3	9	6,704	nw.	35	e.	30	3	8	20	8.0	T.	
Little Rock	357	139	147	29.72	30.11	+.08	43.2	−9.5	65	14	51	24	22	36	29	39	35	75	2.94	−2.0	8	7,285	nw.	33	w.	21	6	10	15	6.4	T.	
Brownsville	57	3	40				59.0		78	28	67	40	9	51	30				1.99		9		n.	30		3						
Corpus Christi	20	69	77	30.06	30.08	+.10	56.0	−8.4	84	30	63	38	8	49	28	51	48	79	2.56	+0.7	8	9,558	n.	48	se.	2	8	9	14	6.4		
Dallas	512	109	117	29.56	30.12		46.4		77	25	55	29	20	38	36				1.93		6	7,480	nw.	40	s.	24	6	11	14	6.3	1.3	
Fort Worth	670	106	114	29.37	30.10	+.12	46.8	−9.8	76	29	56	28	22	38	38	40	34	65	1.40	−0.4	5	8.004	nw.	50	nw.	30	8	4	19	6.6	2.2	
Galveston	54	106	114	30.04	30.10	+.09	53.8	−8.5	72	30	59	38	22	48	20	49	44	75	1.43	−1.5	8	9,752	n.	41	nw.	4	16	6	9	4.6		
Houston	138	111	121	29.95	30.10		53.4	−10.1	84	30	62	32	22	44	32				1.54		6	6,787	n.	46	se.	2	12	7	12	5.1	T.	
Palestine	510	64	72	29.55	30.09	+.09	48.3	−10.2	79	30	57	28	22	40	33	43	39	76	1.96	−1.5	8	6,387	n.	29	nw.	30	8	6	17	6.3	2.1	
San Antonio	701	109	132	29.34	30.08	+.10	53.2	−8.9	88	30	64	29	22	42	41	46	39	67	1.20	−0.5	6	7,125	ne.	32	n.	30	14	6	11	4.7	1.5	
Taylor	582	55	63	29.51	30.13	+.14	49.2	−10.5	83	25	59	28	22	39	40				1.66	−1.0	7	7,716	n.	35	nw.	22	11	6	14	5.8	0.3	

TABLE I.—*Climatological data for United States Weather Bureau stations, March, 1915*—Continued.

Districts and stations.	Elevation of instruments.			Pressure in inches.			Temperature of the air, in degrees Fahrenheit.									Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level, feet.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with 0.01 or more.	Total movement, miles.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
Ohio Valley and Tennessee.							**37.4**	**-6.7**										**69**	**1.78**	**-2.6**										**6.0**		
Chattanooga	762	189	213	29.23	30.06	0.00	43.4	-7.9	67	25	52	25	22	35	31	36	28	60	3.38	-2.8	13	6,634	nw.	32	nw.	16	11	6	14	5.6	2.9	....
Knoxville	996	93	100	28.95	30.03	-.03	41.2	-7.0	64	25	50	24	22	32	31	35	28	64	2.57	-3.0	11	4,277	nw.	22	nw.	16	11	6	14	5.7	6.7	T.
Memphis	399	76	97	29.68	30.12	+.08	42.7	-9.4	63	14	50	27	22	36	24	38	32	70	3.03	-2.7	8	6,741	nw.	35	w.	21	8	8	15	6.2	2.0	....
Nashville	546	168	191	29.49	30.09	+.04	41.3	-7.9	66	25	49	26	2	33	27	35	28	64	2.14	-3.3	9	7,122	nw.	27	nw.	16	8	8	15	6.2	2.1	....
Lexington	989	75	102	28.95	30.05	.00	35.8	-7.6	56	25	43	21	1	28	22				1.49	-3.2	10	6,899	nw.	31	ne.	4	10	6	15	5.7	0.7	....
Louisville	525	219	255	29.50	30.10	+.05	38.6	-6.7	57	25	46	25	1	31	24	33	28	68	1.31	-3.0	9	8,451	w.	40	nw.	16	10	6	15	6.0	T.	....
Evansville	431	72	82	29.60	30.08	+.04	39.0	-5.6	56	14	45	25	1	33	20	34	30	75	1.08	-3.5	7	5,434	nw.	25	sw.	5	7	9	15	6.5	2.5	....
Indianapolis	822	154	164	29.16	30.07	+.03	35.5	-4.1	54	14	42	18	30	28	22	31	25	70	1.47	-2.5	8	6,519	nw.	32	sw.	25	9	5	17	6.0	0.1	....
Terre Haute	575	96	129	29.44	30.07	......	37.0	......	57	14	44	22	30	30	22	33	28	75	1.03	......	8	6,776	nw.	30	n.	16	6	14	11	6.1	0.3	....
Cincinnati	628	152	160	29.37	30.07	+.02	37.5	-5.3	55	14	45	20	30	30	24	33	27	69	1.64	-2.0	8	5,563	nw.	22	ne.	4	12	4	15	5.8	1.8	....
Columbus	824	173	222	29.15	30.05	+.01	34.0	-5.2	53	14	41	16	30	27	23	30	25	71	1.19	-2.0	8	8,870	nw.	37	n.	16	8	10	13	6.4	0.6	....
Dayton	899	181	216	29.05	30.04	......	34.7	-5.6	54	14	42	18	30	28	23	30	25	71	1.19	-2.3	7	7,594	n.	36	n.	16	13	6	12	5.1	1.0	....
Pittsburgh	842	353	410	29.08	30.01	-.03	33.2	-6.3	51	14	40	15	3	26	25	28	22	68	1.26	-1.8	12	9,347	nw.	39	nw.	29	8	11	12	5.5	5.8	....
Elkins	1,940	41	50	27.89	30.03	-.02	31.2	-7.9	51	4	40	13	4	23	38	27	22	74	1.69	-2.4	16	3,460	w.	22	se.	5	3	13	15	7.3	14.8	....
Parkersburg	638	77	84	29.38	30.05	.00	35.4	-6.9	53	14	43	18	30	28	25	31	26	71	1.42	-2.4	6	4,822	nw.	27	nw.	29	11	7	13	5.7	3.0	....
Lower Lake Region.							**29.8**	**-3.1**										**74**	**1.00**	**-1.6**										**5.2**		
Buffalo	767	247	280	29.11	29.97	-.05	27.8	-3.4	44	15	34	13	3	22	19	25	22	83	1.38	-1.2	11	12,250	sw.	50	nw.	2	12	9	10	5.1	12.5	1.0
Canton	448	10	61	29.42	29.91	......	25.2	-2.5	47	23	33	1	4	18	26	......	......	......	0.51	-2.3	7	7,594	w.	38	w.	29	16	11	4	3.4	3.0	T.
Oswego	335	76	91	29.55	29.93	-.08	28.8	-2.6	42	24	34	12	3	24	18	27	23	76	0.53	-2.3	7	8,887	nw.	44	nw.	30	12	6	13	5.2	4.2	1.4
Rochester	523	97	113	29.38	29.97	-.05	29.4	-1.9	48	23	35	14	30	24	21	26	21	74	0.70	-2.2	10	7,858	w.	31	w.	2	12	5	14	5.2	6.0	0.5
Syracuse	597	97	113	29.28	29.94	-.08	28.0	-3.4	49	25	34	11	4	22	22	25	21	76	1.11	-1.3	10	9,500	nw.	41	nw.	26	10	9	12	5.6	10.7	0.3
Erie	714	92	102	29.20	30.00	-.02	29.2	-3.9	43	25	34	16	4	24	19	27	22	74	0.68	-2.0	9	7,626	w.	30	nw.	29	10	11	10	5.3	3.6	0.4
Cleveland	762	190	201	29.18	30.03	.00	30.4	-3.8	46	14	35	16	3	26	23	28	23	73	0.92	-1.9	10	9,039	w	48	w.	29	13	6	12	5.2	3.3	....
Sandusky	629	62	103	29.33	30.03	.00	31.8	-3.4	48	24	38	15	3	26	21	29	24	76	1.17	-1.4	9	9,189	nw.	39	w.	29	11	7	13	5.5	1.1	....
Toledo	628	208	246	29.35	30.05	+.02	33.2	-1.6	54	14	41	12	3	26	26	29	24	69	1.76	-0.5	8	9,872	nw.	46	w.	29	13	5	13	5.0	6.1	....
Fort Wayne	856	113	124	29.11	30.06	......	32.6	-6.3	52	14	40	14	3	25	25	29	24	72	0.80	......	10	6,908	nw.	32	e.	4	12	3	16	5.8	3.4	....
Detroit	730	218	245	29.22	30.03	.00	31.8	-1.1	53	14	39	13	3	24	22	28	23	71	1.24	-1.1	8	9,482	nw.	37	nw.	29	10	10	11	5.5	6.5	....
Upper Lake Region.							**28.5**	**+0.9**										**75**	**0.78**	**-1.5**										**5.4**		
Alpena	609	13	92	29.36	30.05	+.02	26.8	+1.8	45	24	34	6	29	20	28	24	20	75	0.43	-1.6	8	9,543	nw.	44	e.	5	9	15	7	4.8	5.8	T.
Escanaba	612	54	60	29.41	30.10	+.06	26.0	+2.5	47	9	34	0	3	18	26	23	18	76	0.48	-1.5	3	7,553	n.	35	ne.	5	18	5	8	3.9	6.0	T.
Grand Haven	632	54	92	29.36	30.07	+.04	30.2	-0.6	44	24	36	12	3	24	20	27	23	76	1.25	-1.3	9	8,066	nw.	34	e.	5	15	5	11	4.6	7.3	....
Grand Rapids	707	70	87	29.28	30.07	+.04	31.4	-1.6	51	14	39	12	3	24	23	27	23	73	1.13	-1.4	7	4,888	nw.	25	nw.	29	8	8	15	6.2	9.8	....
Houghton	684	62	72	29.36	30.11	+.07	24.8	+1.0	48	12	31	-1	3	18	31	......	......	......	0.63	-1.5	9	6,997	w.	29	e.	5	5	10	16	6.7	5.2	2.0
Lansing	878	11	62	29.07	30.04	......	30.1	-1.2	51	14	40	9	3	21	31	26	21	75	0.78	-1.5	9	4,866	nw.	25	nw.	29	13	6	12	4.9	8.0	....
Ludington	637	60	66	29.35	30.07	......	29.8	......	43	13	35	14	3	24	20	27	24	78	0.55	......	5	7,376	n.	31	w.	29	12	7	12	5.4	4.6	....
Marquette	734	77	111	29.30	30.13	+.09	26.5	+2.8	51	12	33	4	2	20	31	23	19	75	1.60	-0.5	13	7,754	nw.	28	nw.	29	5	8	18	7.2	16.5	7.7
Port Huron	638	70	120	29.31	30.02	-.01	29.0	-0.6	48	14	36	13	29	22	26	26	22	77	0.82	-1.6	9	8,648	nw.	37	nw.	28	7	14	10	5.7	5.5	T.
Saginaw	641	48	82	29.34	30.06	......	29.6	......	50	13	38	9	3	21	25	26	23	78	0.62	-2.0	4	7,306	nw.	34	nw.	29	11	8	12	5.6	6.2	T.
Sault Sainte Marie	614	11	61	29.36	30.08	+.05	24.8	+3.5	46	13	33	0	3	17	27	21	16	74	0.09	-1.8	4	7,781	nw.	38	nw.	2	8	8	15	5.7	0.9	T.
Chicago	823	140	310	29.17	30.08	+.05	34.8	+0.4	57	24	40	21	29	30	22	31	25	70	0.60	-2.0	7	7,909	nw.	31	ne.	4	11	8	12	5.3	3.6	....
Green Bay	617	109	144	29.40	30.08	+.04	28.6	+1.8	48	24	36	5	3	21	26	24	19	70	0.86	-1.5	7	8,304	ne.	35	ne.	7	13	6	12	5.4	7.9	....
Milwaukee	681	119	133	29.32	30.08	+.05	32.1	+1.2	54	24	38	16	3	26	20	29	24	74	1.29	-1.4	6	7,025	w.	36	e.	5	12	8	11	5.0	7.5	....
Duluth	1,133	11	47	28.89	30.16	+.10	25.0	+0.9	48	23	33	-3	2	17	27	22	17	75	0.36	-1.2	9	9,765	nw.	49	ne.	5	13	10	8	4.8	3.5	....
North Dakota.							**23.2**	**+2.4**										**77**	**0.28**	**-0.7**										**4.5**		
Moorhead	940	8	57	29.20	30.26	+.18	23.6	+2.2	46	22	32	-3	2	15	30	22	19	85	0.57	-0.6	4	6,525	n.	28	nw.	24	18	4	9	3.8	5.7	T.
Bismarck	1,674	8	57	28.44	30.31	+.25	24.0	+1.9	50	22	34	-1	8	14	34	20	15	74	0.35	-0.7	6	6,785	nw.	35	nw.	19	15	7	9	4.3	3.3	....
Devils Lake	1,482	11	44	28.60	30.24	+.19	23.8	+5.3	51	23	34	-6	2	14	31	20	16	77	0.09	-0.9	5	8,356	n.	40	n.	19	13	8	10	4.9	0.6	....
Williston	1,872	40	47	28.21	30.28	+.24	21.6	0.0	50	23	32	-4	10	11	40	19	13	71	0.13	-0.6	5	4,435	n.	28	nw.	24	11	11	9	5.0	0.8	T.
Upper Mississippi Valley.							**33.0**	**-3.0**										**76**	**0.79**	**-1.6**										**5.9**		
Minneapolis	918	10	208	29.13	30.25	......	27.8	......	46	23	35	6	2	21	23	......	......	......	0.93	-0.7	8	8,302	nw.	34	n.	28	7	13	11	6.0	14.3	T.
St. Paul	837	201	236	29.22	30.16	+.11	28.0	-0.2	47	24	35	7	2	20	25	......	......	......	0.99	-0.6	8	8,447	n.	38	e.	5	11	10	10	5.4	12.0	....
La Crosse	714	11	48	29.33	30.13	+.09	30.0	-0.9	52	24	38	10	3	22	29	......	......	......	0.49	-1.2	6	4,071	nw.	23	sw.	28	11	7	13	5.7	7.1	....
Madison	974	70	78	29.03	30.12	+.08	29.6	-0.5	51	24	36	11	3	23	22	26	21	72	0.87	-1.3	5	6,974	nw.	31	n.	7	13	7	11	5.1	8.9	....
Charles City	1,015	10	49	29.03	30.15	+.10	27.4	-1.0	49	24	34	8	1	20	29	24	22	85	0.28	-1.6	7	4,875	nw.	22	n.	28	5	19	7	5.6	3.2	....
Davenport	606	71	79	29.43	30.12	+.09	33.0	-2.4	58	24	40	21	9	26	24	29	25	77	0.83	-1.4	8	5,509	nw.	31	e.	4	12	11	8	4.8	6.4	....
Des Moines	861	84	97	29.20	30.14	+.10	31.2	-4.5	56	24	38	10	12	25	23	29	26	80	1.16	-0.5	8	5,382	n.	28	e.	4	5	7	19	7.4	11.3	....
Dubuque	698	81	96	29.36	30.14	+.10	32.0	-1.2	54	24	39	16	9	25	25	28	22	71	1.14	-1.1	6	4,969	nw.	23	ne.	4	10	9	12	5.4	8.5	....
Keokuk	614	64	78	29.43	30.13	+.10	34.0	-3.9	58	24	41	21	9	27	23	31	27	79	0.90	-1.5	8	3,638	nw.	28	ne.	4	10	8	13	5.9	7.0	....
Cairo	356	87	93	29.69	30.08	+.04	40.4	-6.6	64	25	47	24	22	34	26	35	30	70	0.75	-3.3	6	7,035	n.	30	ne.	4	5	12	14	6.7	0.1	....
Peoria	609	11	45	29.43	30.11	+.08	34.1	-2.9	59	24	42	19	29	26	27	30	27	80	0.67	-2.3	10	5,220	nw.	31	ne.	4	11	8	12	5.7	4.1	....
Springfield, Ill	644	10	91	29.39	30.10	+.07	35.8	-3.3	58	24	42	23	29	29	24	31	26	72	0.80	-2.3	11	5,903	nw.	28	ne.	4	5	11	15	6.5	3.7	....
Hannibal	534	74	109	29.52	30.12	+.10	35.2	-6.4	60	24	42	22	29	29	27	......	......	......	0.75	-2.0	10	6,341	nw.	35	ne.	4	7	10	14	6.6	5.5	....
St. Louis	567	265	303	29.48	30.10	+.07	38.5	-5.0	61	24	45	28	29	32	27	33	28	70	0.44	-3.0	10	8,184	nw.	35	sw.	24	6	12	13	6.4	2.0	....
Missouri Valley.							**28.8**	**-7.2**										**83**	**1.51**	**-0.4**										**7.2**		
Columbia, Mo	781	11	84	29.24	30.10	+0.07	35.2	-6.2	63	24	42	22	9	28	28	......	......	......	1.15	-1.9	8	6,263	nw.	32	ne.	4	2	4	25	8.4	8.1	....
Kansas City	963	161	181	29.08	30.14	+.12	34.7	-6.1	54	24	40	21	21	29	19	31	27	75	1.24	-1.6	10	8,824	nw.	32	sw.	24	2	10	19	7.9	13.5	....
St. Joseph	967	11	49	29.08	30.15	......	33.0	......	55	24	39	19	21	27	21	30	26	78	1.36	......	6	6,668	nw.	26	e.	4	4	6	21	7.7	9.8	....
Springfield, Mo	1,324	98	104	28.67	30.12	+.10	35.1	-8.4	59	24	41	19	21	29	26	32	29	82	2.23	-1.8	12	7,414	nw.	26	e.	3	6	11	14	6.5	11.2	....
Iola	984	11	50	29.06	30.14	+.13	34.6	-7.8	56	13	41	14	6	28	24	......	......	......	2.25	-0.1	9	5,747	nw.	23	ne.	25	3	13	15	6.7	14.9	....
Topeka	983	85	101	......	......		33.6	-7.3	58	13	40	16	21	28	25	......	......	......	1.69	-0.6	10	7,238	nw.	27	nw.	20	4	5	22	7.7	11.1	....
Lincoln	1,189	11	84	28.87	30.19	+.17	29.3	-6.7	49	24	35	12	1	23	24	27	24	84	1.66	+0.3	10	8,227	n.	32	nw.	19	4	9	18	7.4	15.7	T.
Omaha	1,105	115	121	28.96	30.19	+.15	30.0	-6.0	48	24	35	16	10	25	19	27	24	80	1.67	+0.3	10	7,251	nw.	30	n.	20	4	7	20	7.5	17.1	....
Valentine	2,598	47	54	27.41	30.25	+.22	21.4	-10.5	44	23	29	-5	9	14	37	20	19	92	1.35	+0.2	15	6,644	w.	30	n.	22	6	7	18	6.9	12.3	5.8
Sioux City	1,135	94	164	28.94	30.20	+.15	26.8	-5.8	46	24	33	2	8	21	22	25	22	85	1.76	+0.5	10	9,252	nw.	36	nw.	19	7	5	19	7.2	16.0	....
Huron	1,306	59	74	28.81	30.28	+.16	20.8	-5.9	39	24	28	-7	11	14	34	20	18	86	1.05	+0.1	6	7,675	nw.	32	nw.	19	7	12	12	5.7	14.3	T.
Pierre	1,572	70	75	28.56	30.32	+.27	20.8	-8.7	44	23	28	-8	11	13	29	19	17	86	0.58	-0.8	7	6,193	nw.	32	nw.	19	8	10	13	6.1	8.0	T.
Yankton	1,233	49	57	28.84	30.22	+.17	23.8	-7.4	41	23	30	-3	9	17	28	......	......	......	1.44	+0.3	9	6,513	nw.	26	nw.	10	4	5	22	7.7	16.1	T.

TABLE I.—*Climatological data for United States Weather Bureau stations, March, 1915*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea level, feet.	Elevation of instruments. Thermometer above ground.	Elevation of instruments. Anemometer above ground.	Pressure in inches. Station, reduced to mean of 24 hours.	Pressure in inches. Sea level, reduced to mean of 24 hours.	Pressure in inches. Departure from normal.	Temperature of the air, in degrees Fahrenheit. Mean max.+mean min.÷2.	Temperature. Departure from normal.	Temperature. Maximum.	Temperature. Date.	Temperature. Mean maximum.	Temperature. Minimum.	Temperature. Date.	Temperature. Mean minimum.	Temperature. Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity, per cent.	Precipitation, inches. Total.	Precipitation. Departure from normal.	Precipitation. Days with 0.01 or more.	Wind. Total movement, miles.	Wind. Prevailing direction.	Wind. Maximum velocity. Miles per hour.	Wind. Maximum velocity. Direction.	Wind. Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Northern Slope.							**30.3**	**− 0.6**										**75**	**0.96**	**− 0.1**										**5.9**		
Havre	2,505	11	44	27.50	30.24	+0.24	24.9	− 2.4	51	21	34	− 4	4	15	31	23	20	84	0.10	− 0.4	4	4,504	e.	23	sw.	21	13	9	9	5.2	0.8	....
Helena	4,110	87	114	25.86	30.13	+ .11	37.8	+ 6.8	65	22	48	5	26	28	32	31	25	65	0.63	− 0.1	3	6,359	sw.	38	sw.	18	11	7	13	5.4	5.4	....
Kalispell	2,962	11	34	27.02	30.14	+ .15	37.1	+ 4.1	61	22	47	16	26	27	35	32	28	74	0.59	− 0.5	8	2,592	w.	13	sw.	18	12	9	10	4.9	0.5	....
Miles City	2,371	26	48	27.64	30.28	+ .26	29.1	+ 0.5	54	21	39	0	8	19	39	25	21	75	0.21	− 0.6	4	3,573	n.	19	n.	27	10	11	10	4.9	1.1	T.
Rapid City	3,259	50	58	26.72	30.30	+ .29	25.4	− 6.2	59	23	33	1	8	17	35	22	17	73	0.87	− 0.2	14	6,443	n.	41	n.	20	8	8	15	6.2	9.0	T.
Cheyenne	6,088	84	101	23.97	30.14	+ .18	27.6	− 5.4	55	23	36	5	4	20	29	24	20	79	1.61	+ 0.7	17	9,168	nw.	42	nw.	22	4	10	17	7.1	16.3	....
Lander	5,372	60	68	24.65	30.12	+ .13	33.4	+ 2.1	64	22	45	3	26	22	40	28	22	66	1.36	− 0.2	11	3,170	sw.	36	ne.	18	8	9	14	6.1	15.0	....
Sheridan	3,790	10	47	26.19	30.21	......	30.2	......	61	23	41	− 3	26	19	35	27	22	75	1.40	......	10	4,123	se.	30	nw.	16	3	15	13	6.7	7.4	....
Yellowstone Park	6,200	11	48	23.87	30.13	+ .11	30.4	+ 3.9	56	22	41	6	4	20	36	25	21	73	1.05	− 1.1	11	4,520	nw.	24	nw.	2	12	5	14	5.2	7.8	T.
North Platte	2,821	11	51	27.19	30.24	+ .24	26.8	− 8.5	58	23	34	− 3	8	19	37	24	21	82	2.25	+ 1.4	14	6,480	n.	32	n.	19	6	4	21	7.3	19.2	T.
Middle Slope.							**34.0**	**− 8.5**										**75**	**1.44**	**0.0**										**6.9**		
Denver	5,291	129	172	24.72	30.12	+ .17	33.6	− 5.1	63	23	43	12	25	24	38	29	24	72	0.91	− 0.1	13	5,785	n.	40	n.	20	2	11	18	7.5	5.6	....
Pueblo	4,685	80	86	25.29	30.08	+ .16	35.0	− 5.6	69	24	46	12	20	24	40	29	22	64	0.48	− 0.4	5	4,677	se.	42	nw.	29	4	20	7	6.1	3.5	....
Concordia	1,398	42	50	28.66	30.19	+ .18	30.6	−10.1	54	24	37	15	6	24	26	28	25	85	2.53	+ 1.0	10	5,518	nw.	23	n.	20	1	12	18	7.9	21.5	T.
Dodge	2,509	11	51	27.50	30.19	+ .22	32.6	− 9.1	68	24	42	13	21	24	34	28	24	76	0.64	− 0.2	7	8,064	n.	38	ne.	24	4	18	9	6.1	5.6	....
Wichita	1,358	139	158	28.66	30.14	+ .15	33.8	−10.3	62	24	40	16	6	27	26	31	26	77	1.97	− 0.3	6	9,315	n.	37	nw.	20	3	12	16	7.2	6.1	....
Oklahoma	1,214	10	47	28.82	30.14	+ .16	38.4	−10.8	71	24	47	19	21	30	35	34	29	74	2.08	− 0.3	10	10,063	n.	42	s.	24	6	10	15	6.5	4.7	....
Southern Slope.							**44.0**	**− 9.2**										**67**	**1.18**	**+ 0.3**										**6.4**		
Abilene	1,738	10	52	28.27	30.11	+ .15	44.8	−10.1	82	24	55	24	20	35	39	38	31	66	0.80	− 0.6	6	7,281	n.	46	nw.	22	5	9	17	7.0	3.0	....
Amarillo	3,676	10	49	26.29	30.10	+ .15	37.2	− 7.8	78	24	48	17	21	27	47	32	27	74	1.00	+ 0.4	6	8,180	n.	40	n.	22	14	12	5	4.3	8.1	0.3
Del Rio	944	64	71	29.07	30.08	+ .13	52.4	− 9.3	83	30	63	32	18	42	38	....	....	....	1.09	− 0.1	5	6,853	se.	39	nw.	19	14	11	6	4.2	2.3	....
Roswell	3,566	75	85	26.38	30.04	+ .14	41.6	− 9.7	77	24	54	17	9	29	43	35	27	62	1.85	+ 1.4	12	5,824	s.	29	e.	20	7	11	13	6.3	6.0	0.6
Southern Plateau.							**48.2**	**− 2.8**										**50**	**0.52**	**0.0**										**3.5**		
El Paso	3,762	110	133	26.17	29.96	+ .08	49.3	− 6.6	76	24	60	26	9	38	34	39	26	48	1.34	+ 1.0	6	9,034	w.	44	nw.	31	13	13	5	4.2	3.5	....
Santa Fe	7,013	57	62	23.17	29.98	+ .09	35.8	− 3.6	62	24	46	14	21	26	34	28	19	58	0.70	0.0	10	5,209	n.	31	se.	1	6	18	7	5.6	7.8	....
Flagstaff	6,908	8	57	......	......	......	32.2	− 3.7	50	23	46	− 9	3	19	46	....	....	....	0.75	......	5	......	w.	36	ne.	17	17	10	4	....	11.4	....
Phoenix	1,108	76	81	28.80	29.96	+ .05	58.6	− 1.9	84	24	72	34	3	46	36	48	37	50	0.33	− 0.2	5	3,866	e.	25	e.	8	19	7	5	3.3	....	....
Yuma	141	9	58	29.81	29.96	+ .02	64.4	− 0.1	91	23	79	36	3	50	42	51	37	44	T.	− 0.4	0	4,070	n.	31	n.	16	26	5	0	1.2	....	....
Independence	3,910	11	42	25.96	29.95	+ .01	49.0	− 0.6	78	24	63	26	6	35	38	....	....	....	0.21	− 0.3	2	5,452	nw.	48	se.	28	18	9	4	3.4	....	....
Middle Plateau.							**43.3**	**+ 2.3**										**50**	**0.60**	**− 0.7**										**5.0**		
Reno	4,532	74	81	25.49	30.06	+ .08	45.0	+ 4.0	76	22	58	24	8	32	44	35	25	53	0.16	− 1.1	4	4,767	w.	39	w.	25	11	10	10	5.2	T.	....
Tonopah	6,090	12	2	24.06	30.01	......	42.6	......	66	22	51	22	5	34	26	34	23	50	0.99	− 0.4	3	5,808	w.	36	nw.	18	11	14	6	4.4	9.5	....
Winnemucca	4,344	18	56	25.64	30.07	+ .06	43.2	+ 3.6	73	22	58	18	19	28	50	34	24	55	0.49	− 0.5	4	4,595	ne.	31	w.	28	12	6	13	5.5	0.7	....
Modena	5,479	10	43	24.61	30.00	+ .04	39.8	+ 0.6	68	24	53	11	2	27	41	31	18	46	0.40	− 0.9	4	7,503	sw.	48	sw.	28	10	12	9	5.1	4.2	....
Salt Lake City	4,360	147	189	25.63	30.02	+ .04	45.1	+ 3.7	66	26	53	29	4	37	25	37	26	49	1.48	− 0.5	5	5,354	nw.	31	nw.	15	10	12	9	5.0	1.9	....
Durango	6,546	10	....	......	......	......	......	......	....	....	....	....	....	....	....	....	....	....	......	......	....	......	......	....	......	....	....	....	....	....	....	....
Grand Junction	4,602	82	96	25.36	29.96	+ .02	43.2	− 0.3	67	26	55	26	4	32	36	33	21	45	0.10	− 0.6	2	4,935	w.	48	nw.	18	10	14	7	5.1	0.1	....
Northern Plateau.							**45.9**	**+ 5.6**										**5.8**	**1.38**	**− 0.2**										**5.7**		
Baker	3,471	48	53	26.50	30.12	+ .09	42.5	+ 7.0	72	22	54	22	6	31	41	36	27	58	1.33	− 0.1	8	4,473	se.	21	w.	15	6	15	8	5.2	0.3	....
Boise	2,739	78	86	27.22	30.10	+ .07	47.2	+ 5.0	71	28	58	27	6	37	35	39	28	50	0.78	− 0.7	5	3,815	se	27	sw.	17	8	8	15	6.0	T.	....
Lewiston	757	40	48	29.29	30.11	+ .08	49.6	+ 5.6	75	21	61	27	8	38	39	....	....	....	1.77	+ 0.5	9	2,336	e.	34	nw.	17	8	11	12	5.6	....	....
Pocatello	4,477	46	54	25.48	30.04	+ .03	41.4	+ 4.5	66	22	52	21	7	31	34	34	25	57	1.33	− 0.4	6	5,961	se.	42	sw.	18	8	13	8	5.3	0.9	....
Spokane	1,929	101	110	28.04	30.12	+ .11	45.0	+ 6.1	71	21	55	26	7	35	37	39	31	62	1.10	− 0.4	10	3,559	ne.	30	w.	17	10	12	13	6.1	T.	....
Walla Walla	1,000	57	65	29.00	30.08	+ .06	49.7	+ 5.7	73	22	59	32	26	41	28	44	36	63	1.96	+ 0.1	10	3,119	s.	29	w.	17	8	11	12	5.8	T.	....
North Pacific Coast Region.							**49.8**	**+ 5.6**										**77**	**3.24**	**− 1.7**										**6.3**		
North Head	211	11	56	29.85	30.08	+ .07	50.4	+ 5.5	72	20	54	40	1	46	17	48	45	85	5.26	0.0	18	11,392	se.	70	s.	17	7	10	14	6.5	....	....
Port Crescent	259	8	53	29.80	30.08	+ .10	45.2	+ 4.7	65	21	53	31	26	38	26	....	....	....	1.88	− 2.0	18	4,066	se.	22	ne.	25	1	17	13	7.0	....	....
Seattle	125	215	250	29.98	30.11	+ .12	50.0	+ 5.8	74	20	57	34	2	43	31	46	43	78	1.72	− 1.9	12	5,705	se.	42	sw.	17	5	10	16	6.8	....	....
Tacoma	213	113	120	29.87	30.10	+ .16	49.8	+ 5.6	72	21	58	33	8	42	33	46	42	76	2.25	− 1.7	16	4,029	sw.	34	sw.	17	8	8	15	6.5	....	....
Tatoosh Island	109	7	57	29.95	30.05	+ .09	49.1	+ 6.2	69	20	53	41	7	45	21	46	43	81	7.64	− 0.9	19	13,127	ne.	58	s.	17	7	6	18	6.6	....	....
Portland, Oreg.	153	68	106	29.92	30.08	+ .06	52.6	+ 6.3	79	21	61	38	2	44	29	47	41	68	2.15	− 3.0	14	4,194	e.	28	sw.	28	9	12	10	5.6	....	....
Roseburg	510	9	57	29.53	30.08	+ .04	51.5	+ 4.9	81	20	62	34	8	41	42	46	41	72	1.76	− 2.2	13	1,874	s.	24	sw.	17	8	17	6	5.4	....	....
Middle Pacific Coast Region.							**54.9**	**+ 3.6**										**71**	**2.12**	**− 2.0**										**5.3**		
Eureka	62	73	89	30.03	30.10	+ .04	52.1	+ 4.1	69	21	58	38	2	46	23	48	45	80	1.65	− 5.3	12	5,035	n.	36	se.	26	8	10	13	6.2	....	....
Mount Tamalpais	2,375	11	18	27.58	30.07	+ .01	50.5	+ 3.4	73	21	56	34	1	46	16	45	40	71	2.14	− 3.0	10	12,514	nw.	64	nw.	4	9	10	12	5.9	....	....
Point Reyes Light	490	7	18	29.51	30.03	......	52.8	+ 3.2	77	21	57	44	8	49	19	....	....	....	2.47	......	10	17,756	nw.	78	nw.	1	10	5	16	6.1	....	....
Red Bluff	332	50	56	29.69	30.05	+ .01	57.0	+ 3.2	83	20	67	39	1	47	33	50	44	67	3.24	− 0.5	9	4,312	nw.	23	n.	1	14	7	10	4.6	....	....
Sacramento	69	106	117	29.98	30.05	+ .02	57.4	+ 3.2	82	22	66	40	2	49	28	50	43	64	1.20	− 1.8	5	5,330	se.	28	se.	27	17	8	6	4.5	....	....
San Francisco	155	209	213	29.90	30.07	+ .01	57.9	+ 5.2	81	22	65	46	7	51	26	52	47	73	3.02	− 0.1	9	5,239	sw.	34	sw.	27	13	9	9	4.7	....	....
San Jose	141	12	110	29.92	30.07	......	56.6	+ 2.9	84	21	67	37	2	46	38	....	....	....	1.49	− 1.5	6	4,375	nw.	21	se.	27	13	6	12	4.8	....	....
South Pacific Coast Region.							**59.4**	**+ 4.2**										**70**	**0.60**	**− 2.0**										**4.5**		
Fresno	327	89	98	29.70	30.06	+ .05	58.4	+ 3.5	84	21	69	40	1	47	32	51	44	66	0.52	− 1.2	3	4,040	nw.	34	sw.	28	11	11	9	4.9	....	....
Los Angeles	338	159	191	29.66	30.02	.00	61.4	+ 5.8	89	16	70	42	2	53	27	54	50	71	0.60	− 2.4	2	4,409	sw.	25	sw.	1	10	14	7	5.0	....	....
San Diego	87	62	70	29.92	30.01	− .01	59.4	+ 3.2	84	21	67	42	3	52	30	53	48	70	0.33	− 1.4	3	4,579	nw.	31	w.	1	18	8	5	3.5	....	....
San Luis Obispo	201	32	40	29.86	30.08	+ .02	58.3	+ 4.5	87	21	70	34	2	47	42	51	47	72	0.95	− 3.0	5	3,265	nw.	24	s.	28	10	11	10	4.7	....	....
West Indies.																																
San Juan	82	8	54	29.87	29.96	− .06	76.8	......	90	22	83	65	12	70	21	....	....	....	1.61	− 1.5	9	7,284	se.	36	ne.	25	19	7	5	3.8	....	....
Panama.																																
Balboa Heights	118	7	97	29.72	29.84	......	83.0	......	93	19	91	71	9	75	19	75	73	82	T.	− 0.7	0	7,086	n.	27	nw.	30	0	23	8	6.3	....	....
Colon	25	5	71	29.83	29.86	......	82.6	......	89	5	86	76	18	79	10	78	76	86	1.71	+ 0.1	12	10,492	n.	32	ne.	24	4	20	7	5.5	....	....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during March, 1915, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	8-9			0.34														(*)			
Albany, N. Y.	22-23			0.05														(*)			
Alpena, Mich.	5-7			0.24														(*)			
Amarillo, Tex.	2-4			0.55														(*)			
Anniston, Ala.	4-5			0.93														(*)			
Asheville, N. C.	4-5			0.67														(*)			
Atlanta, Ga.	4-5			0.88														(*)			
Atlantic City, N. J.	6-7			1.26														(*)			
Augusta, Ga.	4-5			1.12														(*)			
Baker, Oreg.	28-29			0.80														0.18			
Baltimore, Md.	5			1.01														.09			
Bentonville, Ark.	3-4			2.27														.31			
Binghamton, N. Y.	6-7			0.47														(*)			
Birmingham, Ala.	4-5			1.46														(*)			
Bismarck, N. Dak.	3-6			0.37														(*)			
Block Island, R. I.	7			0.12														(*)			
Boise, Idaho	28-29			0.50														.16			
Boston, Mass.	2			T.														(*)			
Buffalo, N. Y.	5-6			0.73														(*)			
Burlington, Vt.	21			0.13														(*)			
Cairo, Ill.	4-5			0.64														.17			
Canton, N. Y.	25-26			0.25														(*)			
Charles City, Iowa	5-7			0.23														(*)			
Charleston, S. C.	5			2.42														.56			
Charlotte, N. C.	4-5			1.60														(*)			
Chattanooga, Tenn.	4-5			1.42														.22			
Cheyenne, Wyo.	25-26			0.53														(*)			
Chicago, Ill.	5			0.47														(*)			
Cincinnati, Ohio	4-5			1.14														.23			
Cleveland, Ohio	5			0.29														.04			
Columbia, Mo.	3-5			0.99														(*)			
Columbia, S. C.	4-5			1.20														(*)			
Columbus, Ohio	5-7			0.89														.13			
Concord, N. H.	2			T.														(*)			
Concordia, Kans.	3-5			1.55														(*)			
Corpus Christi, Tex.	17-18			1.09														(*)			
Davenport, Iowa	4-7			0.72														(*)			
Dayton, Ohio	5-6			0.92														(*)			
Del Rio, Tex.	8-9			0.52														(*)			
Denver, Colo.	3-4			0.37														(*)			
Des Moines, Iowa	3-6			1.00														(*)			
Detroit, Mich.	5-6			0.83														(*)			
Devils Lake, N. Dak.	20			0.04														(*)			
Dodge City, Kans.	2-3			0.36														(*)			
Dubuque, Iowa	5-7			1.10														(*)			
Duluth, Minn.	5			0.14														(*)			
Durango, Colo.																					
Eastport, Me.	26			0.20														0.03			
Elkins, W. Va.	5			0.53														.10			
El Paso, Tex.	8			0.42														(*)			
Erie, Pa.	25			0.19														(*)			
Escanaba, Mich.	5-6			0.38														(*)			
Eureka, Cal.	28-29			0.74														.16			
Evansville, Ind.	4-5			0.78														.16			
Flagstaff, Ariz.	1			0.55														(*)			
Fort Smith, Ark.	29-30			1.28														.40			
Fort Wayne, Ind.	5-7			0.38														(*)			
Fort Worth, Tex.	2-4			1.15														.47			
Fresno, Cal.	27-28			0.39														.12			
Galveston, Tex.	2-4			1.17														.27			
Grand Haven, Mich.	15			0.48														(*)			
Grand Junction, Colo.	1-2			0.10														.04			
Grand Rapids, Mich.	5-6			0.64														(*)			
Green Bay, Wis.	5-7			0.62														(*)			
Hannibal, Mo.	4-7			0.52														(*)			
Harrisburg, Pa.	5-7			1.71														(*)			
Hartford, Conn.	22-23			0.21														.04			
Hatteras, N. C.	5-6			0.36														.07			
Havre, Mont.	18			0.05														(*)			
Helena, Mont.	29			0.33														(*)			
Houghton, Mich.	27-29			0.23														(*)			
Houston, Tex.	2-4			0.92														(*)			
Huron, S. Dak.	2-6			1.03														(*)			
Independence, Cal.	1			0.17														(*)			
Indianapolis, Ind.	4-5			0.86														(*)			
Iola, Kans.	4			1.08														(*)			
Jacksonville, Fla.	30-31			1.25														(*)			
Kalispell, Mont.	29-30			0.27														(*)			
Kansas City, Mo.	3-5			1.07														(*)			
Keokuk, Iowa	4-5			0.47														(*)			
Key West, Fla.	13-14	3:40 p. m.	D. N. a. m.	0.69	12:08 a. m.	12:17 a. m.	0.14	0.20	0.34												
Knoxville, Tenn.	4-5			0.90														(*)			
La Crosse, Wis.	4-6			0.42														(*)			
Lander, Wyo.	24-25			0.48														(*)			
Lansing, Mich.	5-7			0.54														(*)			
Lewiston, Idaho	28-29			1.12														0.14			
Lexington, Ky.	4-5			1.08														.14			
Lincoln, Nebr.	2-5			1.44														(*)			
Little Rock, Ark.	3-4			1.43														(*)			
Los Angeles, Cal.	27-28			0.60														.17			
Louisville, Ky.	4-5			1.02														(*)			
Ludington, Mich.	5-6			0.41														(*)			
Lynchburg, Va.	5-6			0.80														.14			
Macon, Ga.	4-5			1.56														.33			
Madison, Wis.	5-7			0.70														(*)			
Marquette, Mich.	27-29			1.05														(*)			
Memphis, Tenn.	4			1.37														.29			

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during March, 1915, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Meridian, Miss	4			1.06														(*)			
Miami, Fla	5-6			0.51														0.40			
Milwaukee, Wis	5-7			0.89														(*)			
Minneapolis, Minn	4-5			0.67														(*)			
Mobile, Ala	4			2.84														(*)			
Modena, Utah	1			0.36														(*)			
Montgomery, Ala	4-5	9:45 a. m.	3:45 a. m.	2.37	9:01 p. m.	9:09 p. m.	1.65	0.26	0.36												
Moorhead, Minn	5			0.46														(*)			
Mount Tamalpais, Cal	27-28			0.83														.12			
Nantucket, Mass	22			0.13														.09			
Nashville, Tenn	4-5			1.04														.23			
New Haven, Conn	22-23			0.21														.04			
New Orleans, La	3-4	12 m.	3:30 p. m.	1.78	10:25 a. m.	10:34 a. m.	1.10	.11	.32												
New York, N. Y	6-7			1.13														0.10			
Norfolk, Va	5-6			0.72														.28			
Northfield, Vt	25-26			0.16														(*)			
North Head, Wash	11-14			1.87														.24			
North Platte, Nebr	2-6			1.46														(*)			
Oklahoma, Okla	2-4			1.30														.31			
Omaha, Nebr	2-6			1.57														(*)			
Oswego, N. Y	25			0.24														(*)			
Palestine, Tex	3-4			1.48														.29			
Parkersburg, W. Va	5			0.74														.13			
Pensacola, Fla	4	8:05 a. m.	10:20 p. m.	3.38	7:09 p. m.	7:43 p. m.	2.32	0.08	0.28	0.45	0.72	0.81	0.92	1.00							
Peoria, Ill	4-7			0.42														(*)			
Philadelphia, Pa	6-7			0.92														(*)			
Phoenix, Ariz	1-2			0.15														(*)			
Pierre, S. Dak	2-4			0.44														(*)			
Pittsburgh, Pa	5-7			0.91														.22			
Pocatello, Idaho	29			0.90														.15			
Point Reyes Light, Cal	27-28			1.13														.20			
Port Huron, Mich	5-6			0.52														(*)			
Portland, Me	2			0.04														.02			
Portland, Oreg	28-29			0.53														.16			
Providence, R. I	22			0.06														(*)			
Pueblo, Colo	18-19			0.32														(*)			
Raleigh, N. C	5			0.74														(*)			
Rapid City, S. Dak	29-30			0.19														(*)			
Reading, Pa	5-8			1.24														(*)			
Red Bluff, Cal	27-28			2.65														.47			
Reno, Nev	28			0.09														.03			
Richmond, Va	5-6			0.82														.18			
Rochester, N. Y	5-6			0.33														(*)			
Roseburg, Oreg	28			0.31														.10			
Roswell, N. Mex	2-4			0.51														(*)			
Sacramento, Cal	27-28			1.04														.36			
Saginaw, Mich	5			0.50														(*)			
St. Joseph, Mo	3-5			1.31														(*)			
St. Louis, Mo	4-5			0.24														(*)			
St. Paul, Minn	4-5			0.74														(*)			
Salt Lake City, Utah	29			0.88														(*)			
San Antonio, Tex	2-3			0.67														.14			
San Diego, Cal	28			0.18														0.11			
Sand Key, Fla	5	1:25 p. m.	5:45 p. m.	0.86	1:45 p. m.	2:08 p. m.	0.01	0.20	0.39	0.52	0.66	0.73									
Sandusky, Ohio	5			0.54														(*)			
San Francisco, Cal	27-29			1.98														.40			
San Jose, Cal	27-28			0.98														.14			
San Luis Obispo, Cal	27-28			0.77														(*)			
Santa Fe, N. Mex	19			0.22														(*)			
Sault Ste. Marie, Mich	2			0.04														(*)			
Savannah, Ga	4-5			1.40														.39			
Scranton, Pa	6-7			1.15														(*)			
Seattle, Wash	3-4			0.67														(*)			
Sheridan, Wyo	23-25			0.85														(*)			
Shreveport, La	3-4			1.24														.41			
Sioux City, Iowa	2-6			1.60														(*)			
Spokane, Wash	30-31			0.27														(*)			
Springfield, Ill	4-7			0.51														(*)			
Springfield, Mo	3-4			1.19														(*)			
Syracuse, N. Y	6			0.43														(*)			
Tacoma, Wash	13-15			0.72														(*)			
Tampa, Fla	5	D. N. a. m.	7:15 a. m.	0.94	5:54 a. m.	6:07 a. m.	.37	.08	.35	.39											
Tatoosh Island, Wash	13-14			2.58														(*)			
Taylor, Tex	2-4			1.30														.60			
Terre Haute, Ind	4-5			0.58														(*)			
Thomasville, Ga	30-31	5:05 p. m.	3:00 a. m.	1.36	1:55 a. m.	2:06 a. m.	.59	.32	.63	.66											
Toledo, Ohio	5-7			1.26														(*)			
Tonopah, Nev	1-2			0.59														(*)			
Topeka, Kans	3-5			1.26														(*)			
Valentine, Nebr	2-6			0.92														(*)			
Vicksburg, Miss	4			1.73														(*)			
Walla Walla, Wash	4			0.59														(*)			
Washington, D. C	5-6			1.02														(*)			
Wichita, Kans	3-5			1.25														(*)			
Williston, N. Dak	12			0.07														(*)			
Wilmington, N. C	5			0.85														.23			
Winnemucca, Nev	28			0.15														.12			
Wytheville, Va	5			1.24														(*)			
Yankton, S. Dak	2-5			1.33														(*)			
Yellowstone Park, Wyo	29-30			0.40														(*)			

* Self-register dismantled. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE III.—*Data furnished by the Canadian Meteorological Service, March, 1915.*

Stations.	Pressure.			Temperature.						Precipitation.		
	Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Inches.	*Inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F	29.10	29.24	−0.64	32.8	+ 5.1	37.1	28.5	46	22	3.66	−1.10	12.0
Sydney, C. B. I	29.38	29.42	− .46	29.6	+ 3.4	34.2	24.9	50	17	4.32	−0.61	37.0
Halifax, N. S	29.44	29.55	− .39	31.2	+ 2.2	38.4	24.0	54	17	0.30	−5.16	2.5
Yarmouth, N. S	29.56	29.63	− .32	30.5	− 0.3	35.5	25.5	43	15	0.32	−4.53	2.5
Charlottetown, P. E. I	29.48	29.52	− .38	26.9	+ 1.5	31.9	21.9	46	11	1.69	−1.52	15.7
Chatham, N. B	29.59	29.61	− .29	26.6	+ 3.6	34.7	18.4	49	4	3.04	−0.43	28.2
Father Point, Que	29.69	29.71	− .19	21.9	+ 1.6	29.2	14.6	38	2	2.27	−0.46	19.7
Quebec, Que	29.44	29.77	− .19	24.0	+ 2.8	31.5	16.5	43	6	0.42	−2.84	2.6
Montreal, Que	29.63	29.85	− .15	26.4	+ 2.6	32.8	20.0	46	4	0.81	−2.98	4.6
Stonecliffe, Ont	29.34	29.97	− .04	23.8	+ 4.8	34.7	13.0	51	− 5	0.01	−2.05	0.1
Ottawa, Ont	29.63	29.97	− .04	26.4	+ 4.9	34.4	18.4	45	4	0.50	−2.22	1.2
Kingston, Ont	29.61	29.93	− .08	28.4	+ 2.8	36.7	20.2	43	9	0.13	−2.51	0.9
Toronto, Ont	29.55	29.95	− .07	29.9	+ 2.6	37.5	22.4	49	11	0.84	−1.80	7.4
White River, Ont	28.69	30.06	+ .03	15.0	+ 2.8	31.4	− 1.3	45	−28	0.50	−0.88	5.0
Port Stanley, Ont	29.34	30.00	− .03	28.4	+ 1.2	36.2	20.6	46	9	1.15	−1.73	7.3
Southampton, Ont	29.28			26.5	+ 1.8	32.7	20.3	43	10	1.29	−1.36	12.9
Parry Sound, Ont	29.26	29.98	− .04	24.6	+ 3.5	34.9	14.3	47	− 1	0.54	−1.69	5.0
Port Arthur, Ont	29.41	30.15	+ .10	25.5	+ 8.7	36.0	15.0	50	− 7	0.05	−0.92	0.5
Winnipeg, Man	29.39	30.27	+ .18	23.0	+10.7	33.0	13.1	47	−15	0.11	−0.92	1.0
Minnedosa, Man	28.38	30.27	+ .21	22.6	+10.1	33.5	11.7	48	18	0.23	−0.42	2.3
Qu'Appelle, Sask	27.90	30.24	+ .20	23.2	+ 8.3	34.1	12.3	50	−15	0.06	−0.71	0.6
Medicine Hat, Alberta	27.84	30.18	+ .18	28.9	+ 1.4	39.6	18.2	57	1	0.02	−0.74	0.2
Swift Currant, Sask	27.55	30.22	+ .20	26.2	+ 4.2	36.7	15.7	55	3	0.10	−0.71	1.0
Calgary, Alberta	26.49	30.11	+ .16	33.0	+ 6.8	43.9	22.0	66	4	0.06	−0.66	0.5
Banff, Alberta	25.43	30.12	+ .18	32.2	+12.0	44.7	19.7	61	0	0.30	−1.11	2.9
Edmonton, Alberta	27.79	30.15	+ .19	30.5	+ 6.3	41.8	19.2	62	5	0.10	−0.62	1.0
Prince Albert, Sask	28.61	30.23	+ .15	22.1	+10.1	31.4	12.8	47	−10	T.	−0.77	T.
Battleford, Sask	28.46	30.28	+ .22	25.2	+12.1	37.0	13.4	53	− 5	0.00	−0.46	0.0
Kamloops, B. C	28.85	30.17	+ .25	45.2	+ 9.1	54.8	35.6	65	23	0.47	−0.10	0.0
Victoria, B. C	29.82	29.92	− .05	48.6	+ 6.7	54.3	42.9	66	38	1.53	−0.59	0.0
Barkerville, B. C	25.66	30.01	+ .13	32.6	+ 6.5	41.7	23.6	55	10	0.91	−0.98	9.1
Hamilton, Bermuda	29.67	29.84	− .24	57.8	− 4.4	64.4	51.1	69	44	6.70	+1.57	0.0

Chart I. Hydrographs of Several Principal Rivers, March, 1915.

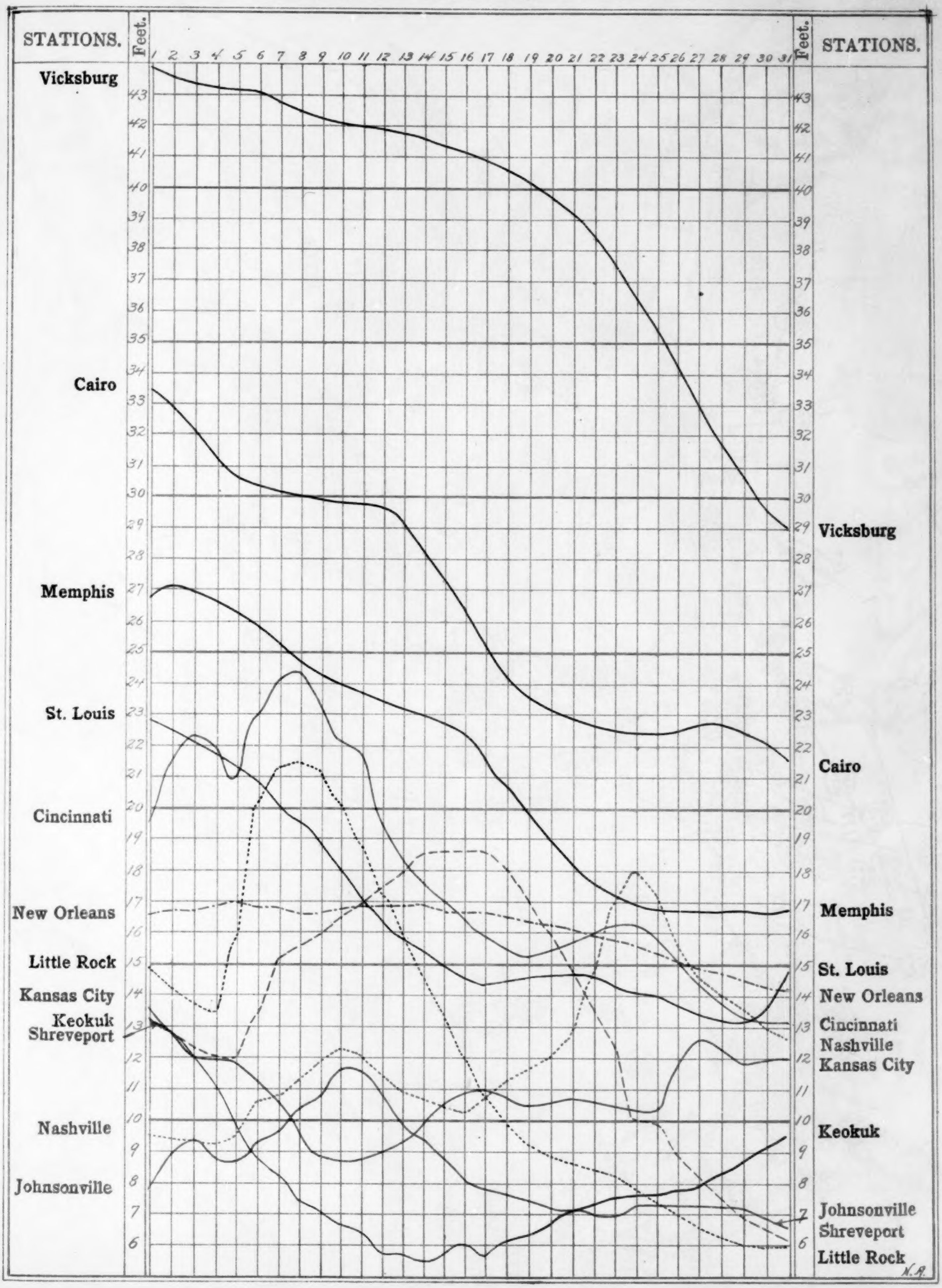

Chart II. Tracks of Centers of High Areas, March, 1915.

(Plotted in Forecast Division.)

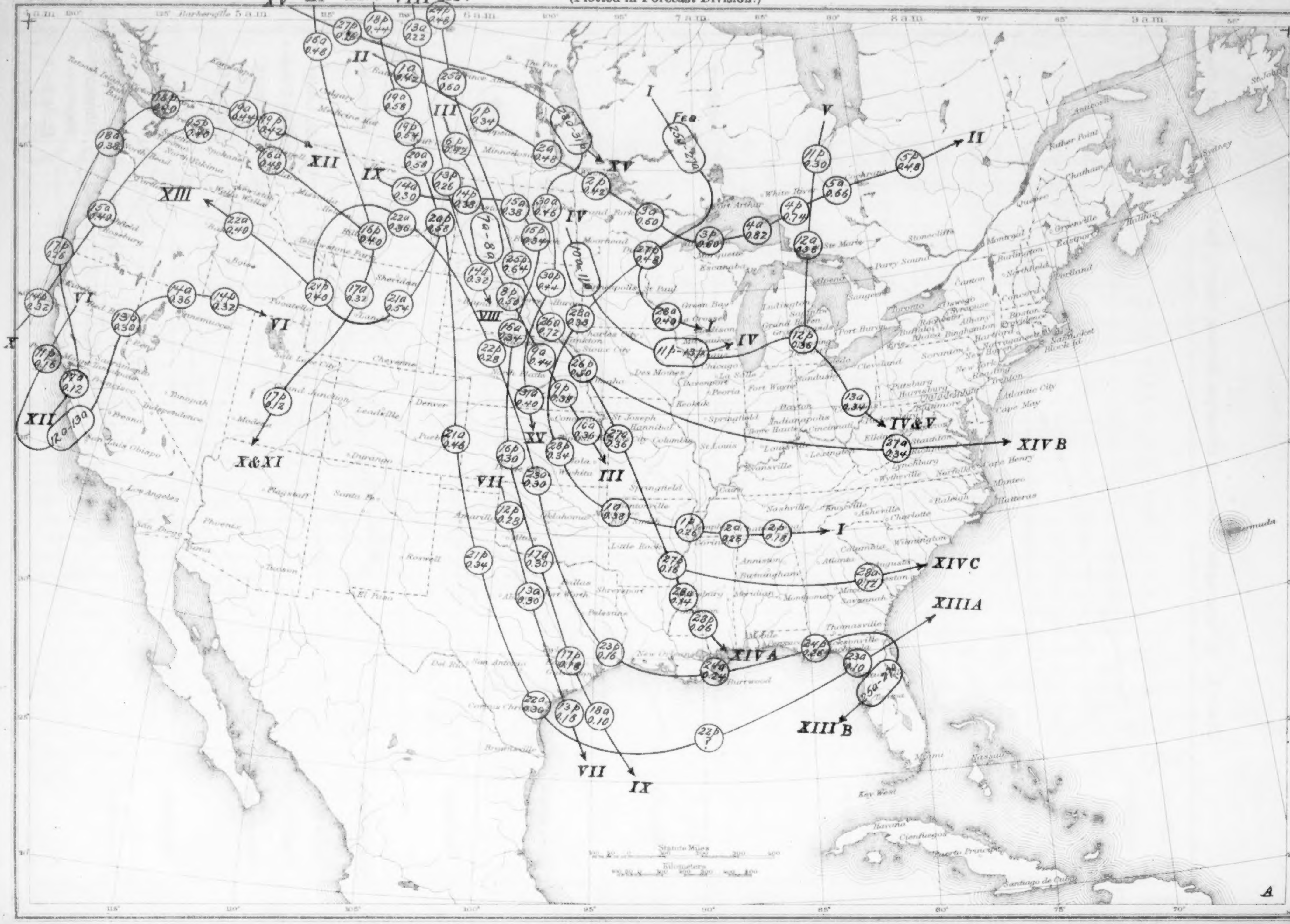

Chart III. Tracks of Centers of Low Areas, March, 1915.

(Plotted in Forecast Division.)

Chart III. Tracks of Centers of Low Areas, March, 1915.

(Plotted in Forecast Division.)

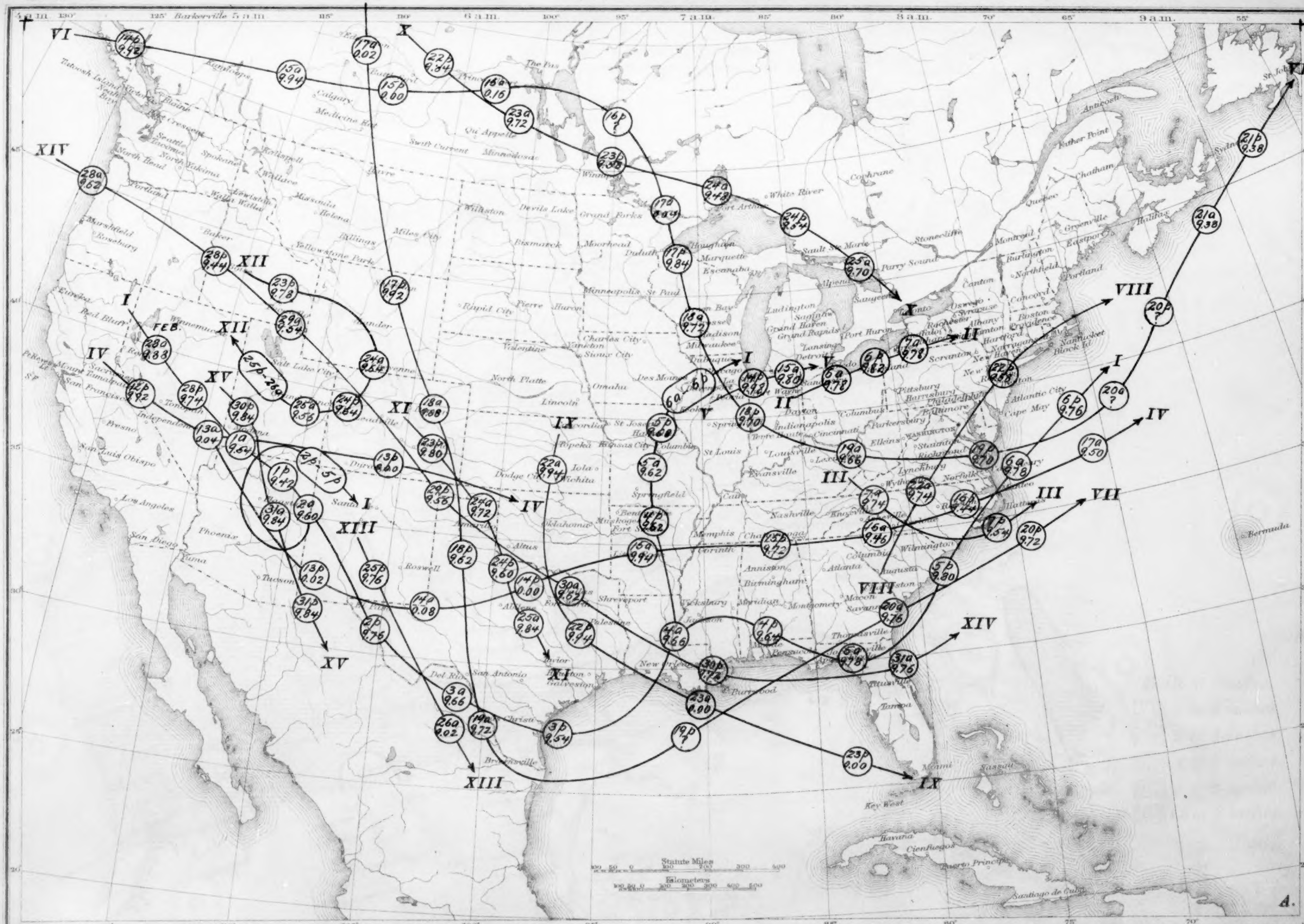

Chart IV. Departure of the Mean Temperature from the Normal, March, 1915.

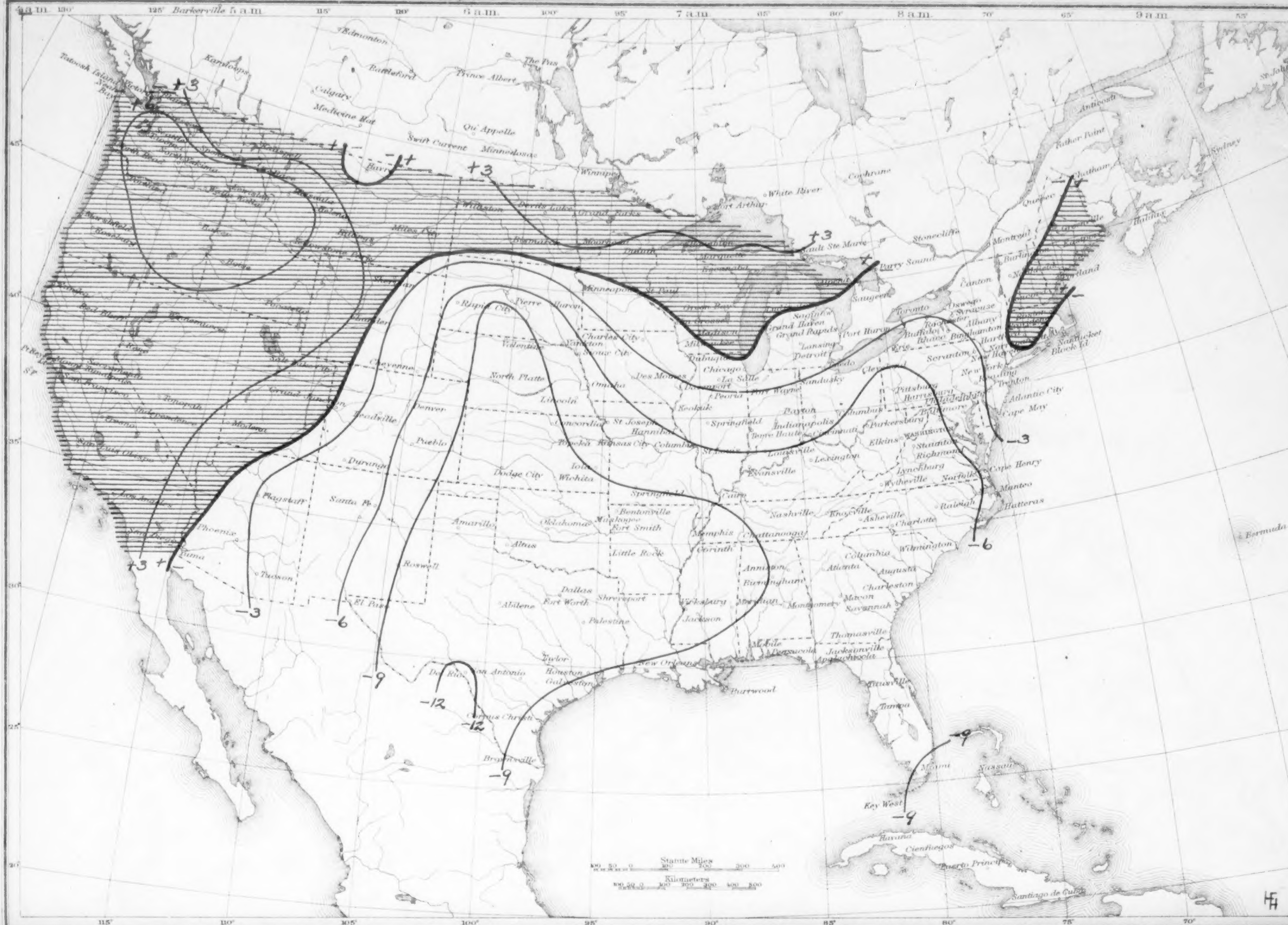

Chart V. Total Precipitation, March, 1915.

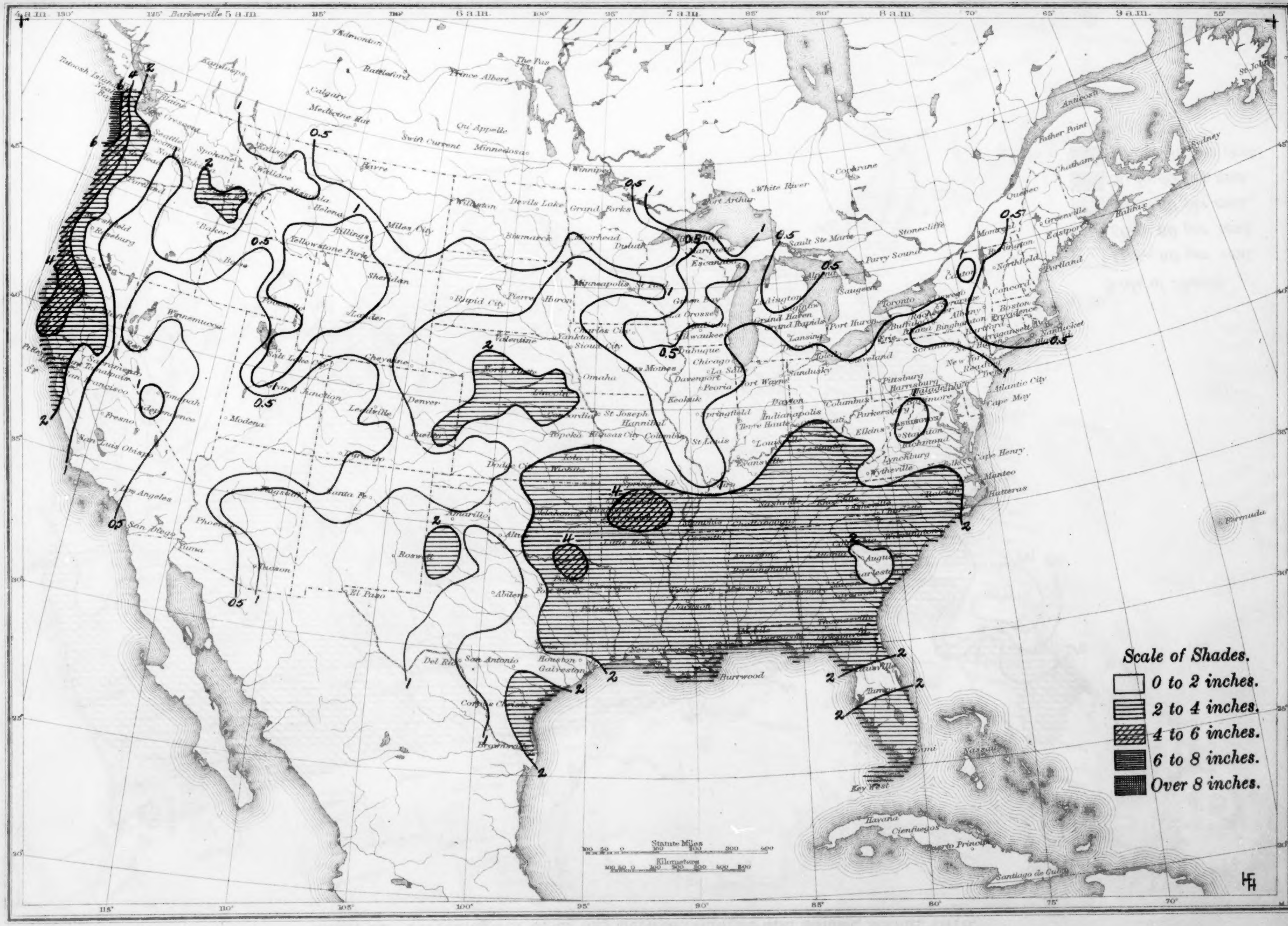

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, March, 1915.

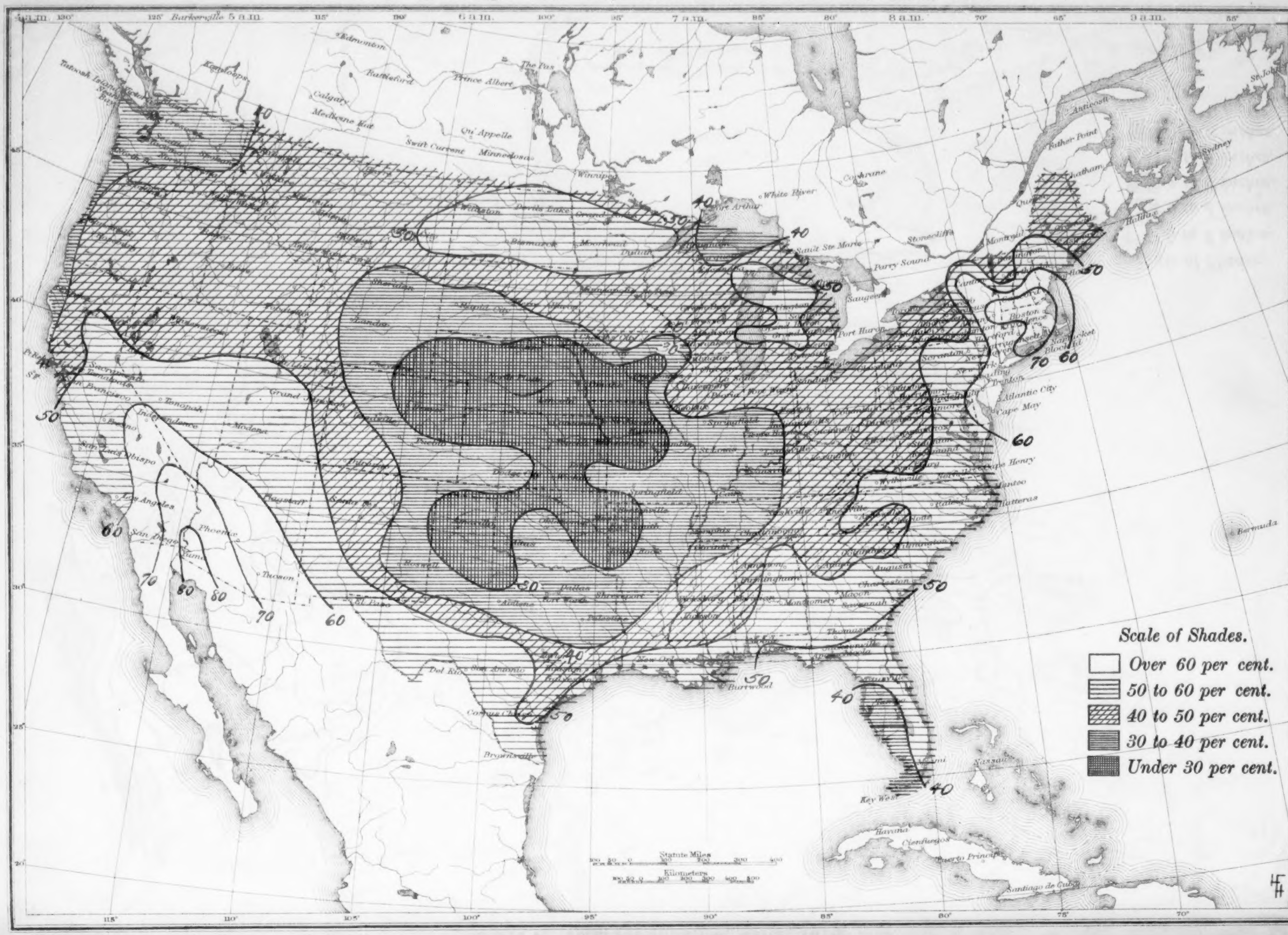

Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, March, 1915.

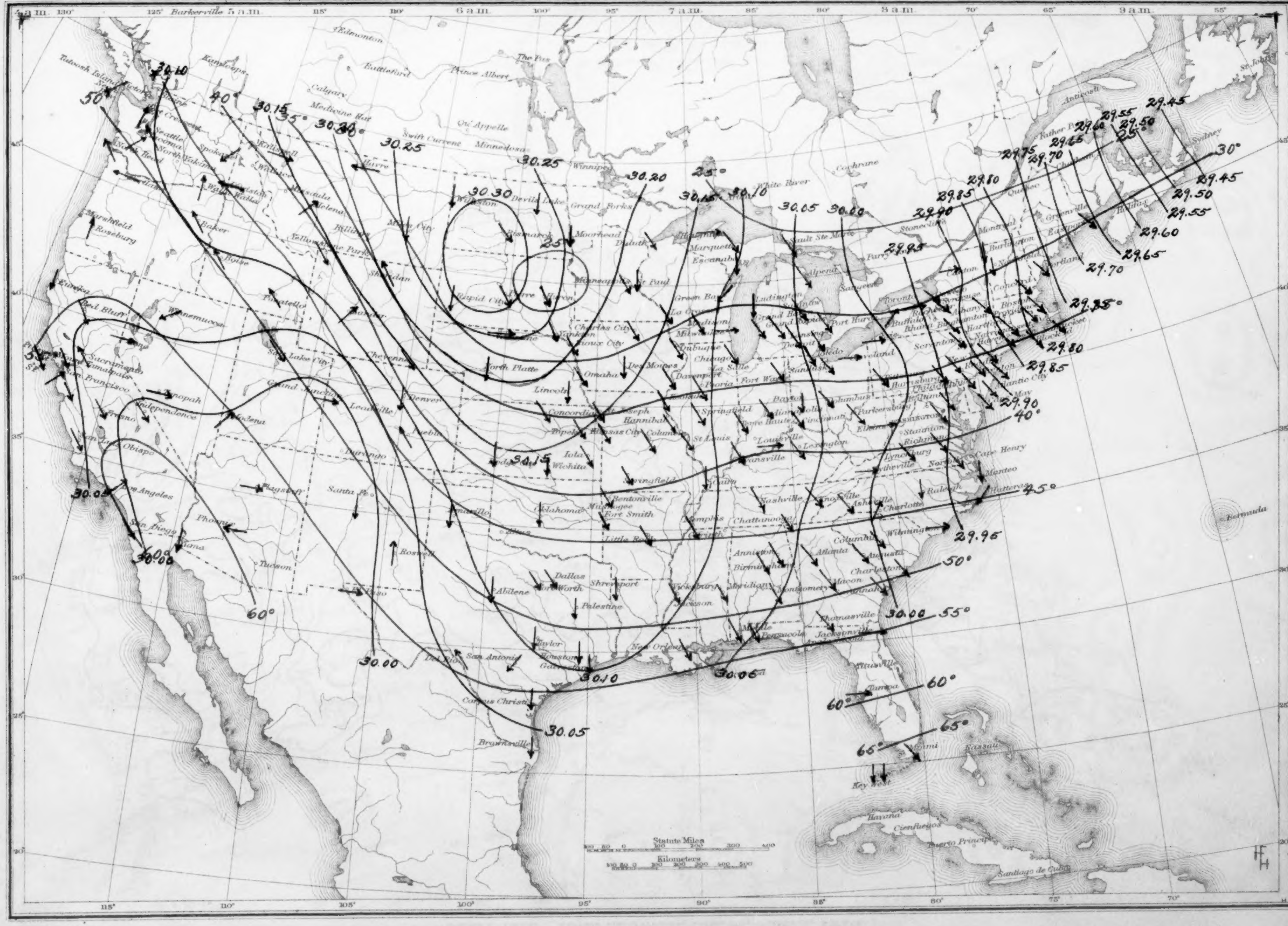

Chart VIII. Total Snowfall, Inches, March, 1915.